Office Of The Secretary Of Defense (OSD)
Deputy Director Of Defense Research & Engineering
Deputy Under Secretary Of Defense (Science & Technology)
Small Business Innovation Research (SBIR)
FY2006.3 Program Description

Introduction

The Deputy Under Secretary of Defense (Science & Technology) SBIR Program is sponsoring six technology themes this solicitation: Human Unmanned System Interaction Technology; Enabling Network Centric Operations Technology; Energy and Power Technology; New Strategic, Tactical, and Missile Defense Energetic Solid Propellant Ingredients Technology; Training of Complex Social, Cultural, and Language Skills Technology; and Defense Health Program Biomedical Technology.

The Army, Navy, Air Force and Defense Health Affairs are participating in the OSD program this year. The service laboratories act as our OSD Agent in the management and execution of the contracts with small businesses. The service laboratories, often referred to as a DoD Component acting on behalf of the OSD, invite small business firms to submit proposals under this Small Business Innovation Research (SBIR) program solicitation. In order to participate in the OSD SBIR Program this year, all potential proposers should register on the DoD SBIR website as soon as you can, and should follow the instruction for electronic submittal of proposals. It is required that all bidders submit their proposal cover sheet, company commercialization report and their firm's technical and cost proposal form electronically through the DoD SBIR/STTR Proposal Submission Website at http://www.dodsbir.net/submission. If you experience problems submitting your proposal, call the help desk (toll free) at 1-866-724-7457. You must include a Company Commercialization Report as part of each proposal you submit; however, it does not count against the proposal page limit. Please note that improper handling of this form may result in the proposal being substantially delayed. Information provided may have a direct impact on the review of the proposal. The DoD SBIR Proposal Submission Website allows your company to come in any time (prior to the proposal submission deadline) to edit your Cover Sheets, Technical and Cost Proposal and Company Commercialization Report.

We <u>WILL NOT</u> accept any proposals that are not submitted through the on-line submission site. The submission site does not limit the overall file size for each electronic proposal, there is only a page limit. However, file uploads may take a great deal of time depending on your file size and your internet server connection speed. If you wish to upload a very large file, it is highly recommended that you submit prior to the deadline submittal date, as the last day is heavily trafficked. You are responsible for performing a virus check on each technical proposal file to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. We will not accept e-mail submissions.

Firms with strong research and development capabilities in science or engineering in any of the topic areas described in this section and with the ability to commercialize the results are encouraged to participate. Subject to availability of funds, the DUSD(S&T) SBIR Program will support high quality research and development proposals of innovative concepts to solve the listed defense-related scientific or engineering problems, especially those concepts that also have high potential for commercialization in the private sector. Objectives of the DUSD(S&T) SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research and development results. The guidelines presented in the solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to DoD and the private sector.

Description of the OSD SBIR Three Phase Program

Phase I is to determine, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the SBIR Program and will typically be one half-person year effort over a period not to exceed six months, with a dollar value up to $100,000. We plan to fund 3 Phase I contracts, on average, and downselect to one

Phase II contract per topic. This is assuming that the proposals are sufficient in quality to fund this many. Proposals should concentrate on that research and development which will significantly contribute to proving the scientific and technical feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes technical performance toward the topic objectives and evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector, in accordance with Section 4.3.

Subsequent Phase II awards will be made to firms on the basis of results from the Phase I effort and the scientific and technical merit of the Phase II proposal in addressing the goals and objectives described in the topic. Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation). Phase II is the principal research and development effort and is expected to produce a well defined deliverable prototype or process. A more comprehensive proposal will be required for Phase II.

Under Phase III, the DoD may award non-SBIR funded follow-on contracts for products or processes, which meet the component mission needs. This solicitation is designed, in part, to encourage the conversion of federally sponsored research and development innovation into private sector applications. The small business is expected to use non-federal capital to pursue private sector applications of the research and development.

This solicitation is for Phase I proposals only. Any proposal submitted under prior SBIR solicitations will not be considered under this solicitation; however, offerors who were not awarded a contract in response to a particular topic under prior SBIR solicitations are free to update or modify and submit the same or modified proposal if it is responsive to any of the topics listed in this section.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and have successfully completed their Phase I efforts, will be invited to submit a Phase II proposal. Invitations to submit Phase II proposals will be released at or before the end of the Phase I period of performance. The decision to invite a Phase II proposal will be made based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in section 4.3. DoD is not obligated to make any awards under Phase I, II, or III. DoD is not responsible for any money expended by the proposer before award of any contract. For specifics regarding the evaluation and award of Phase I or II contracts, please read the front section of this solicitation very carefully. Every Phase II proposal will be reviewed for overall merit based upon the criteria in section 4.3 of this solicitation, repeated below:

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
c. The potential for commercial (defense and private sector) application and the benefits expected to accrue from this commercialization.

In addition, the OSD SBIR Program has a *Phase II Plus* Program, which provides matching SBIR funds to expand an existing Phase II contract that attracts investment funds from a DoD acquisition program or Private sector investments. ***Phase II Plus*** allows for an existing Phase II OSD SBIR contract to be extended for up to one year to perform additional research and development. ***Phase II Plus*** matching funds will be provided on a one-for-one basis up to a <u>maximum $</u>500,000 of SBIR funds. All ***Phase II Plus*** awards are subject to acceptance, review, and selection of candidate projects, are subject to availability of funding, and successful negotiation and award of a ***Phase II Plus*** contract modification. The funds provided by the DoD acquisition program must be obligated on the OSD Phase II contract as a modification prior to or concurrent with the OSD SBIR funds. Private sector funds must be deemed an "outside investor" which may include such entities as another company, an investor, or a non-SBIR/non-STTR government program. It does not include the owners or family members, or affiliates of the small business (13 CFR 121.103).

The Fast Track provisions in section 4.0 of this solicitation apply as follows. Under the Fast Track policy, SBIR projects that attract matching cash from an outside investor for their Phase II effort have an opportunity to receive interim funding between Phases I and II, to be evaluated for Phase II under an expedited process, and to be selected for Phase II award provided they meet or exceed the technical thresholds and have met their Phase I technical goals, as discussed Section 4.5. Under the Fast Track Program, a company submits a Fast Track application, including statement of work and cost estimate, within 120 to 180 days of the award of a Phase I contract (see the Fast Track Application Form on www.dodsbir.net/submission). Also submitted at this time is a commitment of third party funding for Phase II. Subsequently, the company must submit its Phase I Final Report and its Phase II proposal no later than 210 days after the effective date of Phase I, and must certify, within 45 days of being selected for Phase II award, that all matching funds have been transferred to the company. For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals in an expedited manner in accordance with the above criteria, and may select these proposals for Phase II award provided: (1) they meet or exceed selection criteria (a) and (b) above and (2) the project has substantially met its Phase I technical goals (and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). However, selection and award of a Fast Track proposal is not mandated and DoD retains the discretion not to select or fund any Fast Track proposal.

Follow-On Funding

In addition to supporting scientific and engineering research and development, another important goal of the program is conversion of DoD-supported research and development into commercial (both Defense and Private Sector) products. Proposers are encouraged to obtain a contingent commitment for follow-on funding prior to Phase II where it is felt that the research and development has commercialization potential in either a Defense system or the private sector. Proposers who feel that their research and development have the potential to meet Defense system objectives or private sector market needs are encouraged to obtain either non-SBIR DoD follow-on funding or non-federal follow-on funding, for Phase III to pursue commercialization development. The commitment should be obtained during the course of Phase I performance, or early in the Phase II performance. This commitment may be contingent upon the DoD supported development meeting some specific technical objectives in Phase II which if met, would justify funding to pursue further development for commercial (either Defense related or private sector) purposes in Phase III. The recipient will be permitted to obtain commercial rights to any invention made in either Phase I or Phase II, subject to the patent policies stated elsewhere in this solicitation.

Contact with DoD

General informational questions pertaining to proposal instructions contained in this solicitation should be directed to the topic authors and point of contact identified in the topic description section. Proposals should be electronically submitted. Oral communications with DoD personnel regarding the technical content of this solicitation during the pre-solicitation phase are allowed, however, proposal evaluation is conducted only on the written submittal. Oral communications during the pre-solicitation period should be considered informal, and will not be factored into the selection for award of contracts. Oral communications subsequent to the pre-solicitation period, during the Phase I proposal preparation periods are <u>prohibited</u> for reasons of competitive fairness. Refer to the front section of the solicitation for the exact dates.

Proposal Submission

Proposals shall be submitted in response to a specific topic identified in the following topic description sections. The topics listed are the only topics for which proposals will be accepted. Scientific and technical information assistance may be requested by using the SBIR/STTR Interactive Technical Information System (SITIS).

It is required that all bidders submit their proposal cover sheet, company commercialization report and their firm's technical and cost proposal form electronically through the DoD SBIR/STTR Proposal Submission Website at http://www.dodsbir.net/submission. If you experience problems submitting your proposal, call the help desk (toll free) at 866-724-7457. You must include a Company Commercialization Report as part of each proposal you submit; however, it does not count against the proposal page limit. Please note that improper handling of this form may result in the proposal being substantially delayed. Information provided may have a direct impact on the review of the proposal. The proposal submission website allows your company to come in any time (prior to the proposal submission deadline) to edit your Cover Sheets, Technical and Cost Proposal and Company

Commercialization Report. We **WILL NOT accept any proposals which are not submitted through the on-line submission site.** The submission site does not limit the overall file size for each electronic proposal, only the number of pages is limited. However, file uploads may take a great deal of time depending on your file size and your internet server connection speed. You are responsible for performing a virus check on each technical proposal file to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. We will not accept e-mail submissions.

The following pages contain a summary of the technology focus areas, which are followed by the topics.

Human Unmanned System Interaction Technology Focus Area

The DoD is currently investing in a variety of unmanned systems designed for units at the battalion level and below. In many of these cases, there will be significant limitations on the manning available for these systems in terms of both numbers and skill types. Increasing the level of automation can have a significant impact on reducing manning requirements. However, despite many advances in autonomous control technologies, mission management often still requires a human's cognitive skills, judgment, decision-making, and tactical understanding. Further, future unmanned systems missions may require frequent user interactions with the autonomous agents to coordinate autonomous planning and execution with those of manned platforms or units in a dynamic battlespace. This is particularly relevant to the rapidly changing environment of the global war on terrorism with the challenges of littoral and urban operations, the threat of chemical and biological weapons, the difficulty in differentiating enemies from neutral civilians, and the need for better force protection. Because of the major threat that IEDs have posed to troops in Iraq, and the importance that urban and littoral operations have assumed in recent conflicts, mobile robots are being rushed into service in large numbers. However, many of these systems have significant manning requirements in terms of both the numbers and skills of operators required to operate these systems effectively. This is particularly challenging in a dynamic battlespace environment. The need for improved human control and collaboration with these robots is acute. One issue that limits the use of robotic and autonomous systems in urban environments is their inability to recognize and interact with persons who may be either non-combatants or threats. For example, soldiers manning checkpoints are exposed to vehicle-borne IEDs, but replacing them with robots requires advanced capabilities in vision and communication between robots and human subjects.

The Navy is developing Unmanned Surface Vehicles for force protection and counter-terrorism. These are directed against small boat threats, support of GWOT and covert operations for WMD detection and interdiction. In this environment, it will be critical to enable meaningful collaboration between unmanned systems and warfighters in order to take advantage of human cognitive strengths and minimize the impact of both human and autonomous system weaknesses. Humans and robots must be able to: (1) communicate clearly about their goals, abilities, plans, and achievements; (2) collaborate to solve problems, especially when situations exceed autonomous capabilities; and (3) interact via multiple modalities both locally and remotely. To achieve these goals, a number of unaddressed Human-Robot Interaction (HRI) challenges must be addressed. For effective human-robot interaction it is essential that the robots have good models of the humans they are interacting with, or encountering. We must have effective mechanisms for human-robot interaction and communication. Roles and responsibilities must be assigned according to the capabilities of both the human and the robot. It must be easy for the human to effect control, to assess the situation, and to assist the robot. Dialogue is particularly important because it allows the operator to review what has happened, to understand problems each robot has encountered, and to be notified when assistance is needed. For more complex missions, users will need to be supported by interfaces that integrate significant amounts of data at different levels of abstraction and guide their attention to the information that best supports the current tactical situation. At the same time, the interfaces must provide access to information in a manner that supports skilled users in managing complex, unanticipated situations. Humans and robots or autonomous vehicles must coordinate their actions to function as a team, to increase task efficiency and performance.

As part of this technology area, topics address the following:

- Human Robotic Interaction in autonomous operations.
- Computational cognitive models as reasoning agents; affective computing to support social regulation;
- Multi-modal and mixed-initiative interaction; human-guided learning; dynamic autonomy;
- Team collaboration with autonomous vehicle team members; HRI for heterogeneous teams;
- Joint human-robot manipulation and mobility, especially for IED and UXO operations
- Advanced embedded vision supporting HRI, including tracking, gesture and activity recognition.
- Omnidirectional EO/IR and acoustic sensors and software that provide 360 degree awareness around a vehicle, particularly in enclosed urban spaces. (and also for USVs for GWOT) Ability to detection and interaction with humans that approach from any direction. Ability to isolate conversation for automated translators and focus attention on threats.
- Human understanding or mental models of intelligent agents that enhance human robot interaction. Integrated computational theories of human robot interaction.
- Natural language interaction for high-level human control of robotic agents. Robotic speech and face avatar communication capabilities on UGVs and USVs.

The Human Unmanned System Interaction Technology topics are:

OSD06-UM1	Littoral Navigation Autonomy for Unmanned Surface Vehicle (Navy)
OSD06-UM2	Cooperative Tracking of Elusive Dismounts by Human Assisted UAV-UGV (Air Force)
OSD06-UM3	Human-Robot Manipulation for Complex Operations (Navy)
OSD06-UM4	Command and Control of small robotics assets (Army)
OSD06-UM5	Peer-to-Peer Embedded Human Robot Interaction (Navy)
OSD06-UM6	Collaborative and Shared Control of Unmanned Vehicle Systems (Navy)
OSD06-UM7	Affect-Based Computing and Cognitive Models for Unmanned Vehicle Systems (Navy)
OSD06-UM8	UAV – Combat Medic Collaboration for Resupply & Evacuation (Army)

Enabling Network Centric Operations Technology Focus Area

Transformation hinges on the recognition that information is our greatest source of power. Information can be leveraged to allow decision makers at all levels to make better decisions faster and act sooner. Ensuring timely and trusted information is available where it is needed, when it is needed, and to those who need it most is at the heart of the capability needed to conduct Network-Centric Operations (NCO). Transforming to NCO requires people, processes, and technology to work together to enable timely access to information, sharing of information, and collaboration among those involved. Instead of "pushing information out" based on individually engineered and predetermined interfaces, Net-Centricity ensures that a user at any level can both "take what he needs" and "contribute what he knows."

The capability to conduct network-centric operations is identified by the National Defense Strategy as a needed key operational capability. This transformational capability proceeds from the simple proposition that the whole of an integrated and networked force is far more capable than the sum of its parts. The functions of sensing, decision-making, and acting, which often in the past produced islands of stand-alone capability will be able to work effectively together even if they are geographically distributed across the entire battlespace.

Net-centricity will enable distributed, integrated operations not only among the combat forces, but also across all the functions of the Department that support combat power, such as logistics, medical, and intelligence, as well as provide it across all phases of planning, combat, post-combat, and peacetime. To achieve this vision, the legacy mantra to provide information on a need to know basis will be replaced by making information available on a need to share basis within a global information environment that will provide ubiquitous, assured access to information where and when the user needs it.

Achieving the full potential of network-centric operations requires viewing information both as a strategic asset and as a weapon system to be employed in all phases of the Department's missions, to include coalition, government, and other partners. As the National Defense Strategy points out, transforming to a network-centric force will require fundamental changes in processes, policy, and culture.

There are many information assurance issues arising from the DoD's adoption of the Global Information Grid (GIG) construct for implementing net-centric warfare. The GIG vision depicts an enticing future, one where the efficiency and efficacy of the DOD enterprise increase manyfold as the power to command, control and access mission assets begins to extend beyond the center of the enterprise out to where the operators are, i.e., the *edge*. This GIG construct, seductively elegant from a functionality viewpoint, presents serious challenges from a security perspective. The well-understood, if now outmoded, hierarchical approach of the past worked by placing the elements which needed to be most trusted in the place which could be best protected. Strategic information, command and control functions, and the important people who controlled them resided in a notional castle keep. The net-centric approach reduces the *Observe Orient Detect Act (OODA) loop*, or time to react, by not forcing edge players to go back to the center to ask permission to operate or to gain access to resources. It envisions autonomous decision-making at the edge informed by a shared awareness of the operational scenario and the commander's intent. Obviously, though, if edge players do not have to go back to the center in order to act, they must have access, from their location, to the information and privileges previously reserved for those behind the moat. Except they are not behind the moat—they are in the fray. Every edge device thus potentially functions as a portal into the entire enterprise—that's the power of the GIG—but each must do so in a dangerous world. Every edge device becomes a potential threat to the enterprise either as a attack vector or intelligence tool. The GIG will support a massively-distributed enterprise that harnesses the power of a collective whose every node is potentially both a weapon and a sensor, continuously gathering and posting its input into a common operational picture. Such an enterprise offers tremendous power, but requires a revolution in the way we think about trust. The strategic concept of power to the edge pushes not just *access*, but also *authority*, to the edge. In this *distributed trust* model, availability and integrity emerge as essential security services. Though these services received limited attention from our community in the past, they now rival confidentiality in criticality. To support this operational picture a suite of enabling technologies collectively known as *Security to the Edge* must be developed.

The need for additional information assurance research was recognized in the Department's strategic review known as the Quadrennial Defense Review (QDR). Resulting program decisions and guidance have emphasized the need for research in secure mobility for future GIG warfighting networks, automated and adaptable dynamic policy applications, automated network reconfiguration, recovery, and reconstitution.

As part of this technology area topics address the five constituents of the Security to the Edge strategy: Security Management Infrastructure, Trusting the Edge, Secure Mobility, Assured Information Sharing, and Enterprise Health, decribed below:

- Security Management Infrastructure – Today we have a mature Key Management Infrastructure (KMI), built for a communications-centric world where the only access worth guarding was access to crypto. The service-based architecture of the GIG, however, will mediate access to a host of privileges ranging from entry into a data store to ability to reroute a sensor or target a weapon. In order to grant access according to need, we will need the ability to set and enforce policies which change dynamically with the operational situation. A sophisticated decision engine will weigh the evidence for access presented by a requestor node against the criteria implied by the policy assertions of the moment. In this environment, node location and integrity may be as important to the access-granting decision as identity and role.
- Trusting the Edge – Our willingness to trust the edge will depend on two factors: the ability of the edge node to protect itself against a hostile environment, and our ability to interrogate the node to see if it is still trustworthy. Technical security, or how we protect our nodes from physical attack, will experience a renaissance. Since net-centricity is all about agile response to changing scenarios, the GIG will see the proliferation of software implementing even security-critical functions. This software will, however, reside within a clever hybrid hardware/software architecture generally capable of protecting it from compromise, and if not, with the ability to self-monitor and report on its integrity.
- Secure Mobility – The ability to do the mission on the move (OTM) has become critical. In the past, tactical systems could be cordoned off from strategic ones, but in the GIG, tactical and strategic will touch often and will likely become one. In the old paradigm it was acceptable for tactical systems to be less assured than strategic ones because the perishable information they carried had a shorter intelligence life. In the new paradigm, edge operators will access the very heart of the GIG, OTM, via their secure mobile platforms. Secure mobility must maximize access while accommodating the tactical realities such as loss of equipment—all without putting the GIG at risk.
- Assured Information Sharing – In the fully-evolved GIG, the separate system-high networks of today converge into one secure multi-level enterprise. However, even before the networks physically converge they will have had to have converged notionally; a user-centered access-granting paradigm requires that any object be at least hypothetically accessible at any time. Initiatives such as the Trusted Computing Platform along with developments in Multiple Levels of Security (MLS) within one network device now appear poised to help in this long standing problem. Now, driven by profits to be made in areas as diverse as web-hosting, grid computing and digital rights management, industry is on the verge of adopting the ideas and techniques we developed with MLS in mind.
- Enterprise Health – The conceptual framework of the GIG and net-centric warfare requires both local and global perspectives on the state of the network. Vulnerabilities in multiple access points require security awareness down to the node, workstation or sensor. The ability to respond also requires the ability to provide a comprehensive, ubiquitous network operating picture. Research is required to enable the security risk management at all levels of granularity. The increased rapidity of potential attacks also requires autonomic response capabilities. The infrastructure which provisions the nodes with cryptovariables will be the same infrastructure which patches them, which monitors their integrity, which reconfigures them when they are attacked and to which they proactively send intelligence gleaned from their environment.

The Network Centric Operations Technology topics are:

OSD06-IA1	Cross Platform Digital Rights Management (Army)
OSD06-IA2	Artificial Intelligence Technique Applied to Cross-Domain Solution (Army)
OSD06-IA3	Situation Awareness and Impact Assessment for Cyber Network Defense (Air Force)
OSD06-IA4	Multi-Level Voice Over IP (VOIP) Security for Army Environments (Army)
OSD06-IA5	Defensive Cyber Craft Systems (Air Force)
OSD06 IA6	Kernel-mode Software Protection to Prevent Piracy, Reverse Engineering, and Tampering of End-Node Applications (Air Force)
OSD06 IA7	Hardware-assisted Software Anti-Tamper (Air Force)
OSD06-IA8	Software Protection for Embedded Applications (Air Force)

OSD06-IA9	Software Protection to Deter Malicious Forensic Data Collection and Exploitation (Air Force)
OSD06-I10	Software Protection through Specialized Commodity Processors (Air Force)
OSD06-I11	Software Situational Awareness for End-node Authentication (Air Force)
OSD06-I12	Light-weight Virtualization as a Defense against Reverse Engineering (Air Force)
OSD06-I13	Advanced Software Exploitation Prevention (Air Force)

Energy and Power Technology Focus Area

Improvements in electric power will enable transformational new military capabilities. Power can be freed on ships, aircraft, and other platforms for use in advanced weapon and survivability systems, as well as significant enhancements in system flexibility. Potential life cycle and acquisition savings can be had by reduced fuel requirements, maintenance, personnel, logistics, and inventory. The Army's transformation challenge in the Future Combat System is to develop a smaller, lighter, and faster force, utilizing hybrid electric drive, electric armament and protection, and a reduced logistical footprint. The Navy is considering future ship concepts that will count on electric power to enable directed energy weapons, electromagnetic launchers and recovery, and new sensors, as well as supporting significant fuel, maintenance, and manning reductions. The Air Force needs electric power to replace complex mechanical, hydraulic and pneumatic subsystems, and also enable advanced electric armament systems. Improved batteries will support the individual soldier by permitting longer mission durations and reduced weight borne by the soldier. Space based operational capabilities improvements include a more electric architecture for responsive and affordable delivery of mission assets, and powering space based radar systems. Advanced electric power and a family of power components will be an essential enabler for the success of the Departments new "spiral development/evolutionary development" acquisition strategy, as spelled out in the latest acquisition documents, with an emphasis on planned upgrades, "plug and play".

Advances in batteries, chemical double layer capacitors, automotive power conditioning, electrolytics, and fuel cells are providing a technological foundation leading to major advances in electric power. Nevertheless, there exist major technical challenges to achieving the advances required in power and energy density. Among these are novel power generation concepts, batteries with a 2-3 X increase in power density and reduced weight/volume, maturation of high energy density dielectrics for capacitors, high power wide band gap devices for high temperature, high voltage operation, and advanced thermal management.

The Energy and Power Technology topics are:

OSD06-EP1 Sulfur-Tolerant Solid Oxide Fuel Cell (SOFC) Anodes (Air Force)
OSD06-EP2 Innovative Motor and Generator Technologies (Navy)
OSD06-EP3 Novel Processing of Dielectric Films (Air Force)
OSD06-EP4 Oxygen Permeable Membrane for Lithium Air Batteries (Army)
OSD06-EP5 Anode Materials for Rapid Recharge High Energy Density Lithium Ion Batteries (Navy)
OSD06-EP6 Reduced Temperature, High Power Thermal Battery Chemistry (Army)
OSD06-EP7 Robust Silicon Carbide Power Switch Module Technologies (Air Force)
OSD06-EP8 Advanced 50-kW Thermal Management System Demonstration (Air Force)

New Strategic, Tactical, and Missile Defense Energetic Solid Propellant Ingredients Technology Focus Area

The DoD's warfighting and defense capability would significantly benefit from higher performing solid propellants for use on space launch, strategic, tactical and missile defense propulsion systems. However, simultaneously attaining higher energy and density while maintaining acceptable physical and insensitive munitions properties is an extremely challenging goal. Current ingredients are incapable of imparting the desired performance and insensitivity with our current understanding of propellant insensitivity.

Because of sporadic, short-term funding over the past 20 years for advanced energetic ingredient research, and because no coordinated, sustained national effort was established, few new ingredients have surfaced. Concomitantly, the level of effort has declined steadily in the USA and the research chemists in this critical defense area represent an aging force. Meanwhile foreign investments in this area have been sustained and accelerated dramatically.

In order to meet and compete in this technology challenge, and to avoid a technological surprise, focused efforts are needed to identify, synthesize, and characterize new, novel ingredients (fuel, oxidizer, plasticizer, binder, and/or burn rate modifiers) to increase the energy and density of formulated solid propellant mixtures. Increased performance is needed along with acceptable insensitive propellant formulations and meeting other required attributes (hazard classification, aging, cost, performance, etc.) defined by the DoD/NASA/US Industry's Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Program Phase III goals and beyond.

Conception and identification of potential compounds is envisioned along with screening them based on their theoretical performance and other parameters using current modeling capabilities. Sequentially, design research strategies and experimental approaches to synthesize and characterize the key properties of promising new ingredients would be needed; and preparation of sufficient new ingredient quantities in laboratory scale to allow determination of structure and permit the conduct of necessary ingredient stability and sensitivity tests.

Cost will ultimately be key to the ability of a program to use a new ingredient. Consistent with this, developing and refining scale-up synthesis procedure using minimum steps with high output for new characterized compounds to be evaluated in formulated propellant development will be needed. With the larger quantities, evaluation of candidate propellant formulations containing the new characterized ingredients in aging, compatibility, mechanical property, thermal stability, sensitivity and performance characteristics for solid propellant applications will be pursued.

The Solid Propellant Technology topics are:

OSD06-PR1	Solid Propellant Binders for Solid Rocket Motors (Air Force)
OSD06-PR2	Solid Propellant Burn Rate Modifiers for Solid Rocket Motors (Air Force)
OSD06-PR3	Solid Propellant Fuels for Solid Rocket Motors (Air Force)
OSD06-PR4	Solid Propellant Oxidizers for Solid Rocket Motors (Air Force)
OSD06-PR5	Theoretical Estimation Of New Propellant Ingredient Heats Of Condensation (Air Force)

Training of Complex Social, Cultural, and Language Skills Technology Focus Area

The importance of understanding the pre- and post-conflict social, cultural, and language influences on the behavior of our allies, neutral forces, enemy combatants, and terrorist networks has been highlighted recently in a number of contexts (2006 Quadrennial Defense Review, Strategic Planning Guidance, DoD Directive 5161.41E, and DoD Directive 3000.05). DoD planners, tacticians and warfighters had years to analyze and understand our Soviet counterparts during the Cold War. In the current Global War on Terror and in the diversity of possible coalition operations, the timeframe for understanding our adversaries, the cultural terrain and the social environments in which they exist and/or flourish is compressed. Additionally, the globalization of technology has brought diverse peoples together, but has still not fully bridged the gap in understanding between Western and Non-Western societies. Over the last few decades there has been limited investment in human-centered technologies to enable the warfighter in the planning and execution of operations in non-Western regions of the world. Our national security depends upon our ability to operate militarily with socio-cultural agility and effects in these regions. Our forces must be able to not only project military power, but also provide for stability, security, transition, and reconstruction efforts globally. To do this requires, at all levels of our force structure, an appreciation of the intricacies of societal and tribal cultures and the complexity of human-to-human interactions.

This theme seeks innovative technologies, such as serious game environments, that can be used to develop relevant models and to push the envelope on providing new training capabilities in social, cultural and language skills for the deployed warfighter in organizational echelons from combat teams to Joint Task Force Headquarters. Proposed networked training technology and distance learning infrastructure projects should be directed toward pushing didactic training to the operational forces. Topics seek to provide the interactive, dynamic learning environments that would support better cultural awareness. The scope extendsfrom the framework for delivery of cultural and language content to the content itself. The technologies should target junior personnel (E1-E5; O1-O4) who would be most likely to have direct contact with foreign nationals and be immersed in novel situations interacting in an unfamiliar cultural environment. Networkable, remote-capable products are desireable in order to provide Just In Time training. It is vital to provide practical tactical information/knowledge and skills to the warfighter.

The Social, Cultural, and Language Skills Technology topics are:

OSD06-CR1	Navigating the Human Terrain: Development of Cross-Cultural Perspective Taking Skills (Army)
OSD06-CR2	Modeling Culturally Accurate Behavior via Multiplayer Game Environments (Army)
OSD06-CR3	Skill Training in a Cultural Context through Distributed Simulations (Army)
OSD06-CR4	Inserting Cultural Context in Distributed Simulations (Army)
OSD06-CR5	Interactive Learning Environment for Managing Socio-cultural Influences on Human-to-Human Interactions at the Tactical Level (Army)
OSD06-CR6	Interactive Learning Environment for Managing Multinational, Interagency, and Other Interactions in Stability, Security, Transition and Reconstruction Operations (Army)
OSD06-CR7	A Multi-Media Approach to Realistic Social and Cultural Skills Training (Air Force)
OSD06-CR8	Student Modeling in Game Environments for Cultural Skills Training (Air Force)
OSD06-CR9	Training for Socio-Cultural Considerations in Planning (Air Force)

Defense Health Program Biomedical Technology Focus Area

The Department of Defense is aggressively pursuing unified Force Health Protection and Deployment Health surveillance strategies to protect Service members and their families from health hazards associated with military service. Toward that end, DoD is undertaking technology development programs that save lives and promote healthy units and communities while improving both force morale and warfighting capabilities.

The operational force is exposed to health threats throughout the operational continuum, from CONUS fixed facilities (garrison, base, ashore) through deployment, employment, and redeployment. DoD is developing policy and procedures to assess occupational and environmental health threats for all locations. A comprehensive record of current health—and of past health events and resultant exposure levels—will be maintained for as many as 100,000 U.S. military personnel over their entire military-service cycle (the Millennium Cohort Study).

When Force Health Protection capabilities are fully implemented, commanders will have a more complete view of potential health threats. Integration of assessments from health databases and other assessments from intelligence (e.g., about land mines, directed enemy fire, fratricide) and safety (e.g., about injuries, vehicle accidents, explosives, aviation mishaps) will provide a framework for identifying future medical technology capabilities necessary for Force Health Protection.

Ensuring the health of the force encompasses several key capabilities:

- To mobilize, deploy and sustain medical and health surveillance support for any operation requiring military services;
- To maintain and project the continuum of healthcare resources required to provide for the health of the force;
- To operate in conjunction with beneficiary healthcare; and
- To develop training systems which provide realistic rehearsal of emergency medical and surgical procedures and unit-level medical operations.

These capabilities comprise an integrated and focused approach to protect and sustain DoD's most important resource—its Service members and their families—throughout the entire length of service commitment.

The Office of the Secretary of Defense believes that the small-business community can be effective in developing new technology-based approaches to needs in force health protection. Three broad capability areas of particular interest are tools and techniques for near real-time surveillance of the health threats and health status of the Force, for epidemiology research, and for delivery of health education and training unique to the surveillance and epidemiology functions. These are described in more detail below:

- Health Surveillance Planning and Decision Support Tools: Tailorable and targeted software applications that are integrated into the Military Health System's backbone of installed information systems are the essential enabling technology for surveillance. Applications in the areas of decision support tools, data and knowledge management, information visualization technologies including geospatial tools, and artificial intelligence-based appliqués for essential analyses are needed. It is expected that the applications would produce a comprehensive system of risk based assessments, predictions, and courses-of-action utilizing epidemiological, intelligence, environmental exposure, and health information concerning deployed forces. The applications should also allow for predictive modeling of medical readiness scaleable from individuals to the aggregated Force, given such data streams as reported real and somatic symptoms.

- New Methods to Monitor Health Status and Clinical Laboratory Data: Monitoring of health status during deployments is necessary to determine etiologic factors of deployment related health change. Data and information analysis tools are needed to collect and harmonize disparate data and information sources and to provide health status surveillance pre- or post-injury to medical information consumers within and outside of military medical channels. Health monitoring should be for a limited set of indicators, and should yield an unambiguous interpretation of health status. Projects are required to have a strong biological basis and be sensitive to changes in health status based on either real-time measurements from warfighters in an operational environment, clinical laboratory data sources, and/or recorded in-patient or out-patient or trauma registry data.

- Medical Surveillance Training and Learning Tools: Developing and maintaining medical surveillance and medical operational planning/consequence management skills among the personnel of the Military Health System are important aspects of deployment health. Advanced distributed learning, simulation-based training and other computer-based training technology should enable all health-care personnel to plan, respond and manage the future medical surveillance missions, and should assist medical professionals to maintain clinical knowledge and skills related to surveillance. Tools that can be extended to use by the general military population for proactive preventive medicine are desirable. Tools should be based on existing medical and allied health knowledge, should be universally accessible, should allow for unlimited practice, and should be SCORM-compliant in content and in delivery modalities.

The Defense Health Program Biomedical Technology topics are:

OSD06-H01	Bidirectional Inductive On-body Network (BIONET) for Warfighter Physiological Status Monitoring (WPSM) (Army)
OSD06-H02	Volume-Sensing Personal Hydration System (Army)
OSD06-H03	Integrated Medical and Biosurveillance Early Warning System Technology (Air Force)
OSD06-H04	Software to Assess Readiness and Train Medical Support Operations Teams (Air Force)
OSD06-H05	Software Technology for Cancer Epidemiology and Prevention (Air Force)
OSD06-H06	Software Technology for QFT-GIT ELISA Reader (Air Force)
OSD06-H07	Computerized Impact Injury Risk Assessment Tool (Air Force)
OSD06-H08	Global Profile Database to Blood Donor’s identity, Health,Travel History (Air Force)
OSD06-H09	Natural Language Processing (Army)
OSD06-H10	Civilian Medical Records Interface tool for AHLTA and VISTA (Army)
OSD06-H11	Simulation-based Planning and Training Tool for Infectious Disease Outbreak, i.e., Pandemic Influenza (Navy)
OSD06-H12	Multimedia Combat Injury Management Training (Army)

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OSD06-CR7	A Multi-Media Approach to Realistic Social and Cultural Skills Training
OSD06-CR8	Student Modeling in Game Environments for Cultural Skills Training
OSD06-CR9	Training for Socio-Cultural Considerations in Planning
OSD06-EP1	Sulfur-Tolerant Solid Oxide Fuel Cell (SOFC) Anodes
OSD06-EP2	Innovative Motor and Generator Technologies
OSD06-EP3	Novel Processing of Dielectric Films
OSD06-EP4	Oxygen Permeable Membrane for Lithium Air Batteries
OSD06-EP5	Anode Materials for Rapid Recharge High Energy Density Lithium Ion Batteries
OSD06-EP6	Reduced Temperature, High Power Thermal Battery Chemistry
OSD06-EP7	Robust Silicon Carbide Power Switch Module Technologies
OSD06-EP8	Advanced 50-kW Thermal Management System Demonstration
OSD06-H01	Bidirectional Inductive On-body Network (BIONET) for Warfighter Physiological Status Monitoring (WPSM)
OSD06-H02	Volume-Sensing Personal Hydration System
OSD06-H03	Integrated Medical and Biosurveillance Early Warning System Technology
OSD06-H04	Software to Assess Readiness and Train Medical Support Operations Teams
OSD06-H05	Software Technology for Cancer Epidemiology and Prevention
OSD06-H06	Software Technology for QFT-GIT ELISA Reader
OSD06-H07	Computerized Impact Injury Risk Assessment Tool
OSD06-H08	Global Profile Database to Blood Donor’s identity, Health,Travel History
OSD06-H09	Natural Language Processing
OSD06-H10	Civilian Medical Records Interface tool for AHLTA and VISTA
OSD06-H11	Simulation-based Planning and Training Tool for Infectious Disease Outbreak, i.e., Pandemic Influenza
OSD06-H12	Multimedia Combat Injury Management Training
OSD06-IA1	Cross Platform Digital Rights Management
OSD06-IA2	Artificial Intelligence Technique Applied to Cross-Domain Solution
OSD06-IA3	Situation Awareness and Impact Assessment for Cyber Network Defense
OSD06-IA4	Multi-Level Voice Over IP (VOIP) Security for Army Environments
OSD06-IA5	Defensive Cyber Craft Systems
OSD06-IA6	Kernel-mode Software Protection to Prevent Piracy, Reverse Engineering, and Tampering of End-Node Applications
OSD06-IA7	Hardware-assisted Software Anti-Tamper
OSD06-IA8	Software Protection for Embedded Applications
OSD06-IA9	Software Protection to Deter Malicious Forensic Data Collection and Exploitation
OSD06-I10	Software Protection through Specialized Commodity Processors
OSD06-I11	Software Situational Awareness for End-node Authentication
OSD06-I12	Light-weight Virtualization as a Defense against Reverse Engineering
OSD06-I13	Advanced Software Exploitation Prevention
OSD06-PR1	Solid Propellant Binders for Solid Rocket Motors
OSD06-PR2	Solid Propellant Burn rate modifiers for Solid Rocket Motors
OSD06-PR3	Solid Propellant Fuels for Solid Rocket Motors
OSD06-PR4	Solid Propellant Oxidizers for Solid Rocket Motors
OSD06-PR5	Theoretical Estimation Of New Propellant Ingredient Heats Of Condensation
OSD06-UM1	Littoral Navigation Autonomy for Unmanned Surface Vehicle

OSD06-UM2	Cooperative Tracking of Elusive Dismounts by Human Assisted UAV-UGV
OSD06-UM3	Human-Robot Manipulation for Complex Operations
OSD06-UM4	Command and Control of small robotics assets
OSD06-UM5	Peer-to-Peer Embedded Human Robot Interaction
OSD06-UM6	Collaborative and Shared Control of Unmanned Vehicle Systems
OSD06-UM7	Affect-Based Computing and Cognitive Models for Unmanned Vehicle Systems
OSD06-UM8	UAV – Combat Medic Collaboration for Resupply & Evacuation

OSD SBIR 06.3 Topic Descriptions

OSD06-CR1 TITLE: Navigating the Human Terrain: Development of Cross-Cultural Perspective Taking Skills

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Identify and define the cognitive and behavioral skill-set (explicit and implicit knowledge, skills, abilities) necessary for Soldiers and leaders to understand the perspectives of individuals from other cultures and societies. Design and develop a deployable training system designed for the initial acquisition of the identified skill-set.

DESCRIPTION: Clausewitz described war as being reliant on a trinity of primary elements: the government, the army and its leaders, and the people. In modern operations, the last element has arguably become the most important of the three. Insurgency success relies on explicit or tacit support of the local population for supply, recruitment, and cover. Counter-insurgency operations, therefore, have identified the local population - the people - as a critical center of gravity for operational success. This has been notionally described as the 'hearts and minds' campaign in the popular press. Although it may be desirable to truly win the hearts of the local population, at a minimum counter-insurgency forces must develop a relationship with the local populace based on trust and security. Developing this relationship with the local people is an objective of primary importance, and is significantly aided by knowledge of local culture and skills supporting the use of this knowledge when interacting with individuals from the local populace.

Existing cultural training focuses on learning the rules and customs of different cultures from the perspective of an American interacting with members of other cultures. Although this approach may enable trainees to improve their ability to communicate with members of other cultures, it does not focus on the broader capabilities required for developing a full understanding of other cultures. Moreover, this training is limited to providing basic information about cultures in the contemporary operating environment (COE). The skills targeted here will significantly assist the conduct of military operations in the COE as well as providing a foundation for future operations. Specifically, the skills and knowledge targeted here are not specific to any one culture, they are general skills relevant to understanding the perspectives of others from any culture – ethnic, religious, national, or organizational.

In the process of developing cultural competence, Soldiers and leaders must first acquire foundational knowledge and skills, which through systematic and focused practice, they develop into higher order skills. Although focused practice is readily accomplished through game-based simulation and training and results in learning to the point of automaticity, the initial acquisition of cross-cultural foundational knowledge and skills is better approached through other learning methods (e.g., focused readings, group discussions, practical exercises, role-modeling). The focus of the current topic is on the development of a prototype learning and development system to support the initial acquisition of the knowledge and skills supporting cross-cultural perspective taking, a principle element underlying Army requirements related to cultural understanding and language proficiency. The developed system will include a curriculum enabling Soldiers to better understand their own culture as well as other national, ethnic, religious, or regional cultures. It should also provide Soldiers with the skills and knowledge necessary to enable a basic understanding of how individuals from another culture may view a particular situation. Due to the heavy emphasis on cultural skills within the current operational environment, and within this topic, it is expected that cultural expertise will be an important consideration in responses.

PHASE I: Identify component knowledge and skills which support cross-cultural perspective taking, distinguishing between core components and secondary components. Identify potential training delivery methods for initial knowledge acquisition and skill development. Develop storyboards for one sequence of training (i.e., one component skill or body of knowledge), including one or more practical exercises, to demonstrate the viability of the desired approach.

PHASE II: Develop a prototype deployable training system by which Soldiers and leaders can acquire the key core and secondary component skills. The emphasis of this system shall be on initial acquisition of relevant knowledge and basic skills rather than technologies supporting extended skill practice and sustainment (e.g., simulations). The proposed curriculum must be deliverable via web technology or CD-ROM and must be SCORM compliant.

PHASE III DUAL USE APPLICATIONS: This learning system could be used to develop relevant cross-cultural skills where individuals are required to interact with people from other cultures or nations. This capability is of interest to a wide variety of military and civilian organizations within and outside the federal government.

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KEYWORDS: cultural training, cross-cultural skills, perspective taking, cultural understanding

TPOC: Dr. Jay Goodwin
Phone: 703-602-7965
Fax:
Email: jay.goodwin@us.army.mil
2nd TPOC: Dr. Teresa Taylor
Phone: 208-334-9390
Fax:
Email: teresa.z.taylor@us.army.mil

OSD06-CR2 TITLE: Modeling Culturally Accurate Behavior via Multiplayer Game Environments

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop methods to abstract and model the cultural behaviors relevant to various potential military scenarios based on observing and recording the behavior of coalition military or locals.

DESCRIPTION: There is a need for training that fills the gap between acquiring factual knowledge about a culture and applying that knowledge successfully in the field. All too often the descriptions of unfamiliar cultures sound like clichés. It has proven difficult to go from the cliché to its application within a specific situation. Often the resulting cultural lesson seems trivial. There is a lack of nuance. Once Soldiers and leaders have learned the facts and “rules” for interacting with members of a particular culture, they still need to practice their application in realistic settings in order to achieve proficiency. Web-based multiplayer game technologies could provide this training. Moreover, they could capture the data that could then be used to generate representations of culturally derived behavior that have the richness of actual behavior. In multiplayer games individuals control avatars that represent themselves in a virtual world. Through control of their avatars, natives would have a means of playing out a given scenario as they would in the real world. The use of the game allows all behaviors to be observed, captured and analyzed. An example of a scenario might be one in which a U.S. Army sergeant is training a group of Iraqi soldiers. His goal would be to provide them with verbal feedback on their performance in ways that are socially acceptable to Iraqis and do not insult or offend them. The sergeant’s behavior could be varied resulting in realistic responses consistent with Iraqi culture. Asking role players to act out this and other scenarios would provide the data for modelers to abstract culturally realistic behaviors (Harrison and Carroll, 2005) for virtual humans. The live role players could therefore eventually be replaced with simulations. This process will also identify training needs by capturing data on U.S. Soldiers performance during the scenarios. This approach could produce more accurate representations of culture than could be generated from either discussions with social anthropologists or interviews with natives.

PHASE I: The objective of Phase I is to develop the concept for this approach, identify and develop solutions for risk factors and threats to validity, and demonstrate its feasibility. There would appear to be three major reasons why this approach might fail: it might not be possible to perform important cultural behaviors in the game; the role players (whether playing U.S. Soldiers or “natives”) might not respond in a sufficiently realistic manner (because they are role playing); and the form of the simulation might affect the role-playing behavior – a game-like setting might produce different behavior than a live setting simply because of the different context. These issues need to be addressed satisfactorily during Phase I through a combination of research literature review and small-scale trials. The contractor shall develop two representative scenarios that involve interactions between U.S. Soldiers and natives from other cultural backgrounds. Using the scenarios as starting point, the contractor shall plan how these scenarios would be played out in a multiplayer game and in a live simulation Using input from with those native to the culture or cultures chosen, evaluate several multiplayer games to determine if they have the capability to represent the necessary behaviors. Research literature shall be reviewed to determine the extent to which the medium in which the scenarios are carried out is likely to affect the behavior of the role players, and if so, to identify ways to reduce this effect. The contractor shall also determine how culturally relevant behavioral data would be captured and abstracted and what modeling methods would be used to model culturally realistic virtual human behavior.

PHASE II: This phase will result in a prototype system for data capture and modeling which can be used in conjunction with an off-the-shelf multiplayer game The contractor will expand the set of scenarios developed during Phase I to include more varied behavior on the part of the U.S. Soldiers and the natives of another culture. Also based on Phase I, methods for capturing culturally relevant data will be developed and tested. Empirical investigations, using role players from appropriate cultures, shall be undertaken to determine the extent of differences in cultural behavior between live simulations and multiplayer games. The performance data captured will serve as the basis for abstracting and modeling culturally relevant behavior. The models will serve as input to determining the behavior of virtual human semi-automated forces. A desired outcome would be models that could be generated automatically from abstracted cultural data and combined into training scenarios capable of providing Soldiers with practice venues for interacting with people from other cultures..

PHASE III DUAL USE APPLICATIONS: A system to capture and model behaviors of people of other cultures could be used in a wide range of applications. Potential customers within the federal government include other Department of Defense organizations, the State Department, Homeland Security, and the Peace Corps. Police and emergency service personnel in cities with diverse populations constitute another potential market.

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KEYWORDS: multiplayer games, culture, training, simulation, behavioral modeling

TPOC: Stephen Goldberg
Phone: (407) 384-3980
Fax:
Email: Stephen.Goldberg@us.army.mil
2nd TPOC: Dr. Bruce Knerr
Phone: 407-384-3987
Fax:
Email: bruce.knerr@us.army.mil

OSD06-CR3 TITLE: <u>Skill Training in a Cultural Context through Distributed Simulations</u>

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop and evaluate tools and techniques which enhance the use of distributed virtual simulations in training cultural adaptation of military skills.

DESCRIPTION: During the last decade, the United States Army has conducted a wide range of missions, many of which represent significant departures from the Army's primary warfighting mission. In addition to Operation Iraqi Freedom, missions have been conducted to enforce peace agreements, to provide humanitarian assistance, and support disaster relief. Key to these efforts is the application of Full Spectrum Operations, in which missions are executed in the context of cultural understanding (Chiarelli & Michaelis, 2005). Missions are often carried out as part of a multi-national force. Success in these missions often requires junior leaders and Soldiers to interact and communicate personally and effectively with people whose cultures, languages, lifestyle, and beliefs are very different from those found in the US. It has become increasingly clear that strategy, operational plans, and implementing procedures must occur in the context of local cultural constraints in order to be effective (Stofft & Guertner, 1995). Virtual simulations, including distributed, multiplayer, persistent, online gaming technologies have the potential to provide the training capability to rapidly address these new and changing demands.

The training goal is to enable Soldiers to learn adaptive application of mission skills within the specific cultural environment of their Area of Operations. The tools and techniques which provide cultural context will encompass speech recognition and synthesizers, automated language tutoring, and culturally intelligent actors combined within immersive simulations. The cultural context tools and techniques should support interaction in natural ways (e.g., voice and gesture) with team members and computer-controlled entities representing other participants (e.g. civilians) in the training scenarios. The system emphasis should be on providing the cultural knowledge base, simulation objects, controls, gestures, and physics for supporting interpersonal interactions during military, mission-required activities. Key elements of cultural context that need to be enabled through the use of these tools include language, non-verbal communication (body language, facial expressions, etc.), dress, social and religious objects and behaviors, and living conditions. The project goal is to provide easy to use tools and techniques for generating these modeled objects and using them within a training scenario.

PHASE I: Existing technological capabilities and tools applicable to the generation and control of cultural behaviors and objects should be reviewed. The output of Phase I will be a report defining the structure and best available techniques required for prototype tools that can generate objects and behaviors in a distributed, immersive virtual environment enabling military activities within an exemplar cultural environment (including computer generated entities). The phase I effort should also provide functional examples of tools that can create objects and behaviors for use in an exemplar training scenario (e.g. medical operations during Stability and Sustainment Operations following a natural disaster).

PHASE II: A prototype toolset for culturally correct interactions within a bounded mission scenario should be developed, based on the results of the phase I efforts. The prototype need not include a full set of development tools, but nevertheless should include sufficient capability to fully exercise and evaluate the system concept and all of the implemented tools. The evaluation of the cultural context tools and techniques should be evaluated during training scenario use by appropriately experienced military personnel.

PHASE III: The most militarily useful product would consist of a cultural context toolset sufficient for military operators to create a complete set of culturally correct behaviors, avatars, and objects for a core set of military activities in a country or region of interest to the Army. An evaluation of the toolset for capability to generate all required simulation-based avatars, behaviors, and objects should be conducted using available military personnel.

DUAL USE APPLICATIONS: Other potential customers within the federal government include other Department of Defense members, the State Department (training of diplomatic personnel), Homeland Security, and the Peace Corps. Police and emergency service personnel constitute another potential market.

REFERENCES:
1. Chiarelli, P. W., & Michaelis, P. R. (July/August 2005). Winning the Peace: The Requirement for Full-Spectrum Operations. Military Review, 4-17.

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KEYWORDS: Virtual Environments, Virtual Reality, military training, speech recognition, speech synthesis, gesture recognition, intelligent tutor, immersive simulation, virtual simulation

TPOC: Dr. Mike Singer

Phone: (407) 384-3993
Fax:
Email: mike.singer@peostri.army.mil
2nd TPOC: Dr. Bruce Knerr
Phone: 407-384-3987
Fax:
Email: bruce.knerr@us.army.mil

OSD06-CR4 TITLE: Inserting Cultural Context in Distributed Simulations

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop and evaluate Cultural Behavior Generation (CBG) systems, tools, and techniques which will enhance distributed simulations by providing appropriate cultural behaviors for use by the OneSAF Objective System. This should improve the skills of military personnel in fulfilling their missions while interacting and working effectively with people of other cultures.

DESCRIPTION: During the last decade, the U.S. Army has conducted a wide range of missions within the context of very different cultures and languages. Missions have been conducted to enforce peace agreements, to provide humanitarian assistance, and to provide disaster relief. Missions such as these are often carried out as part of a multi-national force. Key to these efforts is the application of Full Spectrum Operations, in which missions are executed in the context of cultural understanding (Chiarelli & Michaelis, 2005). These missions also often require junior leaders and Soldiers to interact and communicate personally and effectively with people whose cultures, languages, lifestyle, and beliefs are very different from those found in the U.S. It has become increasingly clear that strategy, operational plans, and implementing procedures must occur in the context of local cultural constraints in order to be effective (Stofft & Guetner, 1995).

The training goal is to enable Soldiers to learn adaptive application of mission skills within the specific cultural environment of their Area of Operations. When training in virtual simulations, this requires using computer-generated entities created through the OneSAF Objective System (OOS, http://list.onesaf.org/html/index.php) to provide the cultural interaction context.

Trainee interactions with CBG controlled entities should enable practice of military skills in the culturally-specific context in which the mission will take place. The trainees must be able to interact in natural ways (e.g., visual signals and voice) with their team members and CBG entities which represent other participants. Interactions with CBG entities should be focused on behaviors that support the necessary minimal language acquisition and correct cultural adaptation in the context of the mission. The CBG interactions should portray typical roles and actions by the CBG during specific mission-required interactions (e.g. being searched). Key elements of the culture that have to be represented include language, non-verbal communication (gestures, body language, and facial expressions), dress, social and religious practices, living conditions, and reflect recent social and political history for specific geographic regions (possibly as narrowly defined as neighborhoods). The CBG system, techniques, and tools should also be able to use the mission situation and interactions in order to select and generate these appropriate responses, enabling realistic interactions in the training exercise.

The CBG system will focus on the selection and generation of appropriate cultural behaviors rather than the generation of graphics. The system must be able to control entities in OOS (Bowers, 2003). These CBG tools and techniques will encompass knowledge databases, speech recognizers and synthesizers, automated language tutoring techniques, and other aids enabling growth and expansion of the cultural behaviors knowledge system. The goal is to produce an application system which can be combined with OOS to support a wide variety of distributed, interactive and immersive simulations.

PHASE I: The vendor shall review existing technological capabilities and tools applicable to the representation of cultural behaviors in distributed, immersive, multiplayer environments. The CBG system concept that emerges from Phase I is to be based on the integration of best available technologies. One output of Phase I will be a report defining the structure and content of a prototype cultural behaviors system capable of interacting with distributed, immersive virtual environments. The report shall include a draft story-board as an instantiation of the example scenario to be developed (e.g. Stability and Sustainment Operations following a natural disaster). The second product of Phase I should be a functional demonstration of a CBG system capable of emitting correct cultural behaviors (driving a computer generated entity, including specifying speech, gestures, and movement) based on a constrained operational situation.

PHASE II: During Phase II the vendor shall expand upon the phase I efforts by building and evaluating a prototype CBG system for generating a constrained set of mission specific cultural behaviors and interactions. Promising individual tools addressing the development and manipulation of the scripted environment interaction scenarios shall be identified, refined, and integrated. The demonstration of the prototype CBG system need not include a full set of training materials or scenario development tools, but nevertheless should support sufficient training to fully exercise and evaluate the system concept and all of the implemented tools.

PHASE III: Build a militarily useable CBG system, to include a complete set of authoring tools for expanding on the core set of military and civilian interactions, specific to a country or region of interest to the Army. Evaluate the full system and authoring tools using available military personnel. The system should be capable of driving the complete range of individual behaviors required for the selected mission activities.

DUAL USE APPLICATIONS: Potential customers within the federal government include other Department of Defense organizations, the State Department, Homeland Security, and the Peace Corps. Police and emergency service personnel in cities with diverse populations constitute another potential market.

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KEYWORDS: Virtual Environments, Virtual Reality, military training, speech recognition, speech synthesis, gesture recognition, intelligent tutor, immersive simulation, virtual simulation, ONESAF Objective System

TPOC: Dr. Michael Singer
Phone: (407) 384-3993
Fax:
Email: mike.singer@peostri.army.mil
2nd TPOC: Dr. Bruce Knerr
Phone: 407-384-3987
Fax:
Email: bruce.knerr@us.army.mil

OSD06-CR5 TITLE: Interactive Learning Environment for Managing Socio-cultural Influences on Human-to-Human Interactions at the Tactical Level

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: The goal of this SBIR is to develop and rapidly field an interactive, dynamic mission planning tool that increases the cognitive readiness and adaptability of junior military personnel by providing a guided simulation environment in which to prepare for complex interactions with civilians in non-Western regions of the world. This tool will focus on developing interactive, practical exercises and supporting quick reference guides to reinforce socio-cultural understanding of non-Western cultures and to enhance interaction with civilians during routine tasks in Stability, Security, Transition, and Reconstruction (SSTR) operations.

DESCRIPTION: Significant cultural differences between the U.S. and non-Western societies, as individuals and as a nation, have been found to interfere with mission success when cultural knowledge is lacking. To date, pre-deployment training has been limited to information on factual cultural knowledge (e.g., customs, religion, and history) and observable cultural differences (e.g., time, space, dress, and gestures), in addition to the conduct of very expensive live training exercises. Lacking is a means to provide military personnel with an understanding of culturally-based cognitive biases that influence not only non-Western behavior, but their own behavior (e.g., communication styles, risk-taking, activity orientation, or perceptions of inter-relationship power). These biases, when not understood, can impede progress toward mission goals by decreasing trust and creating unwanted second- and third-order effects in the operational environment.

The proposed mission planning tool should provide a dynamic, interactive means for guiding U.S. military personnel in how to apply their cultural understanding in adapting their interactions with military counterparts and civilian people in non-Western cultures, particularly during SSTR operations (see Department of Defense Directive 3000.05). The tool will not only provide practical exercises but also quick reference guides to support conduct of operational tasks involving interactions with non-Western civilians.

PHASE I: Develop overall system design that includes (a) specification of common issues that challenge U.S. military personnel in Mid-East (e.g., Iraq, Afghanistan, Saudi Arabia, Iran, Kuwait, Sudan) and other countries in their interactions with their military counterparts and the civilian population at large during SSTR operations; (b) approaches and behaviors that have worked well in dealing with these issues and challenges; (c) approaches that have not been successful and should be avoided; and (d) complex cultural, social, and language background information that is relevant to interpersonal interactions.

System design activity would include, but is not limited to, an exhaustive search for and review of existing military or commercial products, a comprehensive literature review, and interviews. Interviews would be conducted with U.S. military personnel across branches of service and with representative civilian foreign nationals. Native-language interviews would include U.S. military personnel and civilian foreign nationals in order to incorporate their perspectives as well.

PHASE II: Develop and demonstrate a networked, remote-capable, SCORM-compliant, rapidly deployable prototype system in a current theatre of operations. Conduct testing to prove feasibility over extended operating conditions with multiple cultures, societal levels, and language ability within the target population. The prototype will be designed to inform junior personnel operating at the tactical-level of their personal strengths and weaknesses, based on validated assessment surveys, regarding specific social and cultural dimensions identified in the literature that impact human-to-human interactions with non-Westerners. The tool will go beyond just presenting cultural knowledge, as it will also provide practice in and specific guidelines for adapting one’s behavior and language for specific operational tasks that involve interactions with non-Western civilians. This tool will also feature downloadable quick reference guides for further mission planning.

PHASE III DUAL USE APPLICATIONS: Groundwork would be laid so that the system could be rapidly scaleable to other cultures (e.g., Asia, Africa). It could be used in a broad range of military and civilian applications where understanding social, cultural, and language influences on behavior is critical for U.S. commercial and military success in SSTR operations.

KEYWORDS: adaptability, cognitive readiness, cultural understanding, human-to-human interaction, operational tasks, practical exercises, quick-reference guide

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TPOC: Dr. Melissa W. Dixon
Phone: 410-278-8824
Fax:
Email: mdixon@arl.army.mil
2nd TPOC: Dr. Linda G. Pierce
Phone: 410-278-5846
Fax:
Email: lpierce@arl.army.mil
3rd TPOC: Dr. Janet L. Sutton
Phone: 937-656-4316
Fax:
Email: janet.sutton@wpafb.af.mil
4th TPOC: LTC Michael Whetstone
Phone: 757-203-6790
Fax:
Email: michael.whetstone@jfcom.mil

OSD06-CR6 TITLE: Interactive Learning Environment for Managing Multinational, Interagency, and Other Interactions in Stability, Security, Transition and Reconstruction Operations

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: The goal of this SBIR is to develop and rapidly field an interactive, dynamic mission planning tool that increases the cognitive readiness and adaptability of U.S. military forces by providing a guided simulation environment in which to prepare for complex interactions with Coalitions composed of multinational forces (MNFs), other U.S. and foreign government agencies (OGAs), and non-government organizations (NGOs). This tool will focus on developing interactive, practical exercises and supporting quick reference guides to reinforce socio-cultural-organizational understanding of these groups to enhance interaction with them during Stability, Security, Transition, and Reconstruction (SSTR) operations.

DESCRIPTION: Significant organizational and cultural differences exist between the U.S. military, MNFs, OGAs, and NGOs, and these differences are known to interfere with mission success when cultural understanding is lacking. To date, pre-deployment training has been limited to mainly factual knowledge of and some practice with foreign military groups, but almost no training considers how best to work with U.S. and foreign OGAs or with NGOs. Lacking is a means to provide U.S. military personnel with an understanding of the inherent cognitive and cultural differences that exist between organizations that influence their own and others' behavior (e.g., organizational structures, communication styles, risk-taking, activity orientation, or perceptions of inter-relationship power). These biases, when not understood, can impede progress toward mission goals by decreasing trust and creating unwanted second- and third-order effects in the operational environment.

The proposed mission planning tool should provide a dynamic, interactive means for guiding U.S. military personnel in how to apply their organizational and cultural understanding in adapting their interactions with MNFs, OGAs, and NGOs during SSTR operations (see Department of Defense Directive 3000.05). The tool will not only provide practical exercises but also quick reference guides to support conduct of Coalition tasks involving interactions with different organizations (i.e., MNFs, OGAs, and NGOs).

PHASE I: Develop overall system design that includes (a) specification of common issues that challenge U.S. military personnel during SSTR operations in their interactions with MNFs, OGAs, and NGOs; (b) approaches and behaviors that have worked well in dealing with these issues and challenges; (c) approaches that have not been successful and should be avoided; and (d) complex organizational, cultural, social, and language background information that is relevant to interpersonal interactions.

System design activity would include, but is not limited to, an exhaustive search for and review of existing military or commercial products, a comprehensive literature review, and interviews. Interviews would be conducted with U.S. military personnel across branches of service, as well as with Coalition MNFs, OGAs (e.g., Department of

State, Department of Homeland Security), and NGOs. Native-language interviews would include U.S. and Coalition counterparts in order to incorporate their perspectives as well.

PHASE II: Develop and demonstrate a networked, remote-capable, SCORM-compliant, rapidly deployable prototype system in a current theatre of operations. Conduct testing to prove feasibility over extended operating conditions with multiple organizations, cultures, and language ability within the target population. The prototype will be designed to inform military personnel operating in SSTR operations of their personal strengths and weaknesses, based on validated assessment surveys, regarding specific organizational, social, and cultural dimensions identified in the literature that impact human-to-human interactions with MNFs, OGAs, and NGOs. The tool will go beyond just raising organizational and cultural awareness through knowledge, as it will also provide practice in and specific guidelines for adapting one's behavior and language for specific Coalition tasks that involve interactions with partners from MNFs, OGAs, and NGOs. This tool will also feature downloadable quick reference guides for further mission planning.

PHASE III DUAL USE APPLICATIONS: Groundwork would be laid so that the system could be rapidly scaleable to include other groups and organizations. It could be used in a broad range of military and civilian applications where an understanding of organizational, social, cultural, and language influences on behavior is critical for U.S. commercial and military success.

KEYWORDS: adaptability, coalition, cognitive readiness, culture, government, human-to-human interaction, multinational, non-government, organizational, practical exercise, quick-reference guide

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TPOC: Dr. Linda G. Pierce
Phone: 410-278-5846
Fax:
Email: lpierce@arl.army.mil
2nd TPOC: Dr. Melissa Dixon
Phone: 410-278-8824
Fax:
Email: mdixon@arl.army.mil
3rd TPOC: LTC Michael Whetstone
Phone: 757-203-6790
Fax:
Email: michael.whetstone@jfcom.mil

OSD06-CR7 TITLE: <u>A Multi-Media Approach to Realistic Social and Cultural Skills Training</u>

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a multi-media training capability to support acquisition of cultural skills for a Non-Western country.

DESCRIPTION: When social and cultural normative behaviors are substantially different from those practiced in Western countries, social and cultural familiarization is essential to government and business operations (Brett, 2001). This requirement is well understood in military operations. The US Army National Training Center at Fort Irwin, California, provides first-hand experience in Iraqi culture and provides field training for acquiring such skills prior to overseas deployment of personnel (National Defense, 2006). Field training for this purpose could be supplemented with advanced technology. For example, McCollum, Deaton, Barba, Santerelli, Singer, and Kerr

(20004) describe VECTOR (Virtual Environment Cultural Training for Operational Readiness) for supplementary cultural training. VECTOR is a well considered, meticulously designed capability that exploits the latest advances in game technology and provides an economical option for training support. However, an alternative approach based on multiple media including text, animations, video clips, photographic stills, audio files, and computer simulations could provide trainees with more realistic illustrations of a broader range of social and cultural experiences. The goal is to develop a training capability to support acquisition of basic skills required for social influence and persuasion (Gass and Seiter, 2003) where success depends on understanding the historical context and social and cultural normative behaviors of the selected, Non-Western country in which the audience resides. The science and technology challenge is to formulate a sound pedagogical approach for ensuring trainee assessment and feedback for learning based on an interactive training capability that blends multiple media to provide the highest fidelity and realism in historical, social and cultural training. For military markets, assume trainees would consist of law enforcement and security officers and non-commissioned officers possessing junior to mid-level rank who are conducting missions in support of operations other than war. The primary language for conveying training content will be English. However, introduction of foreign language terminology to facilitate understanding social and cultural normative behaviors is encouraged. Familiarization with the foreign language associated with the selected, Non-Western country should be included as a learning objective. It is desirable that the capability be web-enabled for distributed training. Although team training is an important consideration, for economy of effort, the intent of this innovation research project is to concentrate on individual training. Sharable Content Object Reference Model (SCORM) standards should be considered for development of computer-based instruction (Thropp, 2004). High Level Architecture standards should be considered for development of distributed, computer-driven simulations (Defense Modeling and Simulation Office, 2005). Work-centered design (Eggleston, R.G., 2003) should be considered as a guide for developing a usable human-computer interface. Innovative and creative approaches to achieving the objective are encouraged.

PHASE I: Generate a top-level design and proof-of-concept exemplar for an interactive, multi-media training capability for a selected, Non-Western country.

PHASE II: After completing Phase I, develop, demonstrate, and evaluate the training effectiveness of the interactive, web-enabled, multi-media training capability designed to support acquisition of historical knowledge and social and cultural skills for the selected, Non-Western country.

PHASE III DUAL USE APPLICATION: Military applications include supplementary computer-based instruction for personnel preparing for “country training” prior to deployment. Other commercial applications include “country training” for non-military, government and business operations in the global market place.

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KEYWORDS: multi-media instruction, computer-based training, computer-based instruction, social training, cultural training, computer-driven training simulations.

TPOC: Dr. Joseph Weeks
Phone: (480) 988-6561
Fax: (480) 988 - 6285
Email: joseph.weeks@mesa.afmc.af.mil
2nd TPOC: Alicia Bledsoe
Phone: 480-988-6561
Fax:
Email: alicia.bledsoe@mesa.afmc.af.mil

OSD06-CR8 TITLE: Student Modeling in Game Environments for Cultural Skills Training

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop robust approach to student modeling to support a game environment for cultural skills training.

DESCRIPTION: When social and cultural normative behaviors are substantially different from those practiced in Western countries, social, and cultural familiarization is essential to government and business operations (Brett, 2001). This requirement is well understood in military operations. The US Army National Training Center at Fort Irwin, California, provides first-hand experience in Iraqi culture and provides field training for acquiring such skills prior to overseas deployment of personnel (National Defense, 2006). Field training for this purpose could be supplemented with advanced training technology. For example, McCollum, Deaton, Barba, Santerelli, Singer, and Kerr (20004) describe a game-based approach to cultural training that provides student feedback based on scores derived from the student's selection of utterances. Cramer, Ramachandran, and Viera (2004) describe a game-based approach to social engineering training that similarly provides feedback based on scores derived from the student's selection of utterances.

Although both approaches are well considered and exploit the latest advances in game technology, they lack a robust approach to student modeling to support performance assessment and feedback. Gaming technology must take into account the current state of the student and the objective state of the student that the instruction is intended to produce. The overall goal is to develop a training capability that supports acquisition of basic skills required for social influence and persuasion (Gass and Seiter, 2003) where success depends on understanding the historical context and social and cultural normative behaviors of the selected non-Western country. The technology challenge for this innovation project is to develop a game environment for cultural skills training that incorporates a robust student modeling approach in support of student performance assessment and feedback. For military markets, assume trainees would consist of law enforcement and security officers and non-commissioned officers possessing junior to mid-level rank who are conducting missions in support of operations other than war. The language for conveying training content will be English. In addition, the trainee would be expected to communicate in English with synthetic characters; however, voice recognition is not necessarily a requirement. Language skills training for the selected, Non-Western country is not a primary learning objective; however, introduction of foreign language terminology to facilitate understanding social and cultural normative behaviors is encouraged. It is desirable that the game environment be web-enabled to support distributed training. Although team training is an important consideration, for economy of effort, the intent of this innovation research project is to concentrate on individual training. Sharable Content Object Reference Model (SCORM) standards should be considered for development of computer-based instruction (Thropp, 2004). High Level Architecture standards should be considered for development of distributed, computer-driven simulations (Defense Modeling and Simulation Office, 2005). Work-centered design (Eggleston, R.G., 2003) should be considered as a guide for developing a usable human-computer interface. Innovative and creative approaches to achieving the objective are encouraged.

PHASE I: Generate a top-level design, proof-of-concept and game exemplar that incorporates robust student modeling to support performance assessment and feedback for cultural skills training.

PHASE II: After completing Phase I, develop, demonstrate, and evaluate the training effectiveness of the game approach to training with robust student modeling to support performance assessment and feedback for cultural skills training.

PHASE III DUAL USE APPLICATION: Military applications include supplementary computer-based instruction for personnel preparing for “country training” prior to deployment. Other commercial applications include “country training” for non-military, government and business operations in the global market place.

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KEYWORDS: computer-based training, computer-based instruction, social training, cultural training, computer games, intelligent tutoring systems, computer-driven training simulations, influence, persuasion

TPOC:	Dr. Joseph Weeks
Phone:	(480) 988-6561
Fax:	(480) 988 - 6285
Email:	joseph.weeks@mesa.afmc.af.mil
2nd TPOC:	Alicia Bledsoe
Phone:	480-988-6561
Fax:	
Email:	alicia.bledsoe@mesa.afmc.af.mil

OSD06-CR9 TITLE: Training for Socio-Cultural Considerations in Planning

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Design and develop the capability to train USAF Air and Space Operations Center (AOC) planners to effectively include socio-cultural considerations in strategic planning.

DESCRIPTION: The AOC is a USAF weapons system providing the ability to direct and supervise air assets in a specified area of operations. Typically, the AOC is responsible for developing and maintaining the strategies and plans for the air assets' contributions to completing an overall mission. The overall mission may range from being primarily military in nature (e.g. Operation Iraqi Freedom) to non-military (e.g. Operation Unified Assistance). But, in all cases, missions involve operations and interactions with a populace (or populaces) with distinguishable socio-cultural characteristics. AOC planners must, in their planning and assessment activities, take into consideration these socio-cultural characteristics, especially in the case of stability, security, transition, and/or reconstruction operations. AOC planners' training in socio-cultural considerations is currently ad hoc, and can be improved through specific training.
This is a solicitation for the capability (1) to train AOC planners in principles of considering socio-cultural characteristics and (2) to evaluate the effect of that training. No training media or methods are specified, but a notional implementation might consist of training with instrumented, simulated scenarios in which mission success would be dependent on socio-cultural variables, followed by feedback based on possibly automated content analysis of the planning process and the planning product.

PHASE I: Design an instrumented training environment for AOC planning mediated by socio-cultural considerations. Specify a training module that incorporates at least one socio-cultural consideration and demonstrate this module under laboratory conditions.

PHASE II: Develop and demonstrate a follow-on prototype training implementation for AOC planners in a realistic environment. Demonstrate the effectiveness of the implementation.

PHASE III DUAL USE APPLICATIONS: The training developed under this effort has straightforward extensibility to helping improve military, diplomatic, and commercial interactions with different societies and cultures.

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KEYWORDS: Cultural awareness, strategic planning, socio-cultural variables, effects based planning, intercultural training

TPOC: Dr. William R Bickley
Phone: 480 988 6561
Fax:
Email:

OSD06-EP1 TITLE: Sulfur-Tolerant Solid Oxide Fuel Cell (SOFC) Anodes

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: DDR&E EPTI

OBJECTIVE: To develop a SOFC that is capable of stable operation with high sulfur content logistic (JP-8) fuels for forward-deployable applications.

DESCRIPTION: Recently, interest in solid oxide fuel cells (SOFC) has increased largely due to the SOFC potential for high system efficiencies and tolerance to carbon monoxide-rich fuel streams. From a military perspective, SOFCs are particularly appealing because they could enable operation on reformed logistic fuels, including JP-8, JP-5, and NATO F-76. While these fuel sources are particularly energy dense, they are extremely complex in

composition and contain a number of impurities and additives which present many challenges for compact electrochemical power generation. Among the most significant of these challenges is the high sulfur content in these fuels. JP fuels can contain as much as 3,000 ppm sulfur, while Navy fuels (NATO F-76, etc.) could include as much as 10,000 ppm. Many of the sulfur compounds present in these fuel streams are mildly reactive and, therefore, are relatively easy to remove. However, there are also considerable quantities of more complex sulfur compounds, including substituted thiophenes which can be particularly difficult to remove via conventional adsorption processes. Upstream removal of these sulfur-containing compounds is being actively researched. However, if suitable materials and processes could be identified, it seems probable that sulfur-tolerant fuel cell anodes could be developed which would significantly decrease system complexity while improving performance.
Conventional SOFCs utilize Ni/yttria-stabilized zirconia (YSZ) cermet anodes which are rapidly poisoned by sulfur contents as low as 2 ppm H₂S at 1273 K in fuel reformate. As such, it will be necessary to explore alternative anode formulations or advanced operation methods to provide increased sulfur tolerance. The objective of this topic is to examine the factors which influence sulfur adsorption and catalyst poisoning on the SOFC anode. This information should then be used to guide selection of novel anode compositions and process methods which improve the performance and longevity of SOFCs operating on a sulfur containing reformates.

PHASE I: Examine factors which influence deactivation of SOFC anode catalysts by sulfur-containing species and propose a novel method or anode formulation which mitigates this performance loss. Experimentally demonstrate that the concept exhibits considerable promise toward achieving stable, long-term operation on high-sulfur-content reformates.

PHASE II: Refine promising concepts developed under the Phase I effort and evaluate them under relevant SOFC environments. Demonstrate a SOFC short stack (> 75 W) which is capable of long-term operation (>200 hours) on H₂S-doped logistic fuel reformate at power densities >300 mW/cm² and fuel utilization >60 percent. Present a plan for incorporating the novel concept or anode formulation into a SOFC-based power system. Sufficient demonstration of the merits of the technology shall be presented relative to conventional approaches defined in terms of system simplification, cost reduction, or performance improvement.

DUAL USE COMMERCIALIZATION: Military applications include ground power units for tent city and flight application. Potential commercial applications include auxiliary power units for class 8 trucks and remote sites.

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KEYWORDS: solid oxide fuel cells, sulfur-tolerant anodes, sulfur-resistant SOFC, fuel cell power units, JP-8, logistic fuels

TPOC: Thomas Reitz
Phone: (937) 255-4275
Fax: (937) 656-7529

Email: thomas.reitz@wpafb.af.mil

OSD06-EP2 TITLE: Innovative Motor and Generator Technologies

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: DDR&E EPTI

OBJECTIVE: Develop and demonstrate significant innovations in electric motor and generator technologies to substantially improve the torque density, power density, and efficiency of these rotating machines.

DESCRIPTION: Electric power has become increasingly critical for our military for a wide variety of applications. Compact, high torque motors with variable speed drives are increasingly being used in propulsion applications for ground, sea, and air vehicles. Motor-driven pumps and fans remain ubiquitous. Variable speed electric motors are increasingly being used in actuator applications previously dominated by hydraulics. The burgeoning demand for electricity on military platforms also increases the need for very compact electric generators that can be direct coupled to high speed prime movers.

The goal of this effort is to develop and demonstrate technologies that will lead to significant improvements in torque density, power density, and efficiency of electric motors and generators. Techniques for realizing this goal include but are not limited to the following: innovations in design to decrease structural mass; improved materials and design approaches to allow increases in tip speed, advanced materials and designs to increase magnetic field in the air gap, advanced conductors to increase current density, and advanced thermal management techniques.

PHASE I: Perform a study to examine the practicality and potential benefits of the innovative technology or technologies being considered. Develop a preliminary machine design targeted at an application of interest to the military, and show the potential benefits in that application, compared to existing technology. Identify sources of supply for any unique materials or components needed. Define manufacturing and assembly techniques. Conduct prototyping and testing of key components or materials at the bench-top level. Develop plans for scale up and demonstration.

PHASE II: Design, fabricate, and test a complete prototype machine (motor or generator) at an appropriate size scale to show the benefits in a real military application. Power levels should be notionally demonstrated in the 50-100kW range, and where necessary, depending on design type and objectives, validate scalability beyond 100kW.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR should be applicable to a wide variety of military and dual use applications, such as hybrid-electric vehicles, more electric aircraft, commercial ships, industrial plant, and utility applications.

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KEYWORDS: electric, motor, generator, power electronics, circuits, conductors, magnetic materials, thermal management

TPOC: Lynn Petersen
Phone: (703) 696-1291
Fax: (703) 696-0934
Email: petersl@onr.navy.mil

OSD06-EP3 TITLE: Novel Processing of Dielectric Films

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: DDR&E EPTI

OBJECTIVE: Develop high-performance, state-of-the-art dielectric materials that have high breakdown strength through novel processing methods to enable leading-edge, pulse-power, high-energy-density (>15 J/g) capability with milliseconds to nanoseconds delivery rates (burst mode).

DESCRIPTION: Compact, high-energy-density, pulse-power capacitors will be the enabling technology for all future weapon systems that the DoD plans to pursue. These capacitors will be used in pulse-forming networks (PFNs) for the conversion of prime electrical energy into short pulses needed to energize loads that are required for directed energy and kinetic energy weapons and high-power microwaves. Therefore, research objectives include a strong emphasis on thin, flexible dielectrics with an extremely high voltage breakdown strength (> 700 MV/m), a dielectric constant greater than 2.2, and low loss (0.1 percent). The proposal could focus on novel thin uniform dielectric materials that are pinhole free, composite or hybrid films with an ordered dispersed nanoparticle phase, surface treatment methods, or other novel film structures that will enable leading-edge, pulse-power, high-energy-density (>15 J/g) capacitor capabilities with delivery rates in milliseconds to nanoseconds. The process should be capable of scaling up to produce large areas of thin and flexible dielectric films for kilojoules-size capacitors. The proposed research should provide a substantial reduction in size, weight, and volume of the capacitor component over state-of-the-art devices while delivering superior electrical and thermal performance.

PHASE I: Demonstrate innovative dielectric film fabrication processes or approaches with substantial improvement in increased mechanical strength, resistivity, voltage breakdown strength, and decreased dissipation factor. Prototype laboratory capacitors should be fabricated and tested to demonstrate the feasibility of the proposed dielectric film fabrication processes.

PHASE II: Demonstrate the optimized development of prototype capacitor components using innovative dielectric material/impregnant, metallization, advanced high density packaging, manufacturing technology, or a combination of these developments. Actual application testing should be performed and electrical, thermal, and life assessments made based on mission scenarios. System issues such as safety, maintainability, supportability, reliability, and mechanical robustness (shock, vibration, etc.) also should be addressed.

DUAL USE COMMERCIALIZATION: Military unique materials/capacitors will provide excellent margins for the high-end commercial sector. Potential applications include electric utilities, aircraft engine ignition systems, medical defibrillators, mobile power systems, solid-state switch snubbers, and deep oil/well drilling, to name a few.

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KEYWORDS: dielectrics, capacitors, impregnants, pulse-forming networks, power electronics, pulse power, energy storage

TPOC:	CPT Kevin Wiacek
Phone:	(937) 255-7564
Fax:	(937) 255-3221
Email:	kevin.wiacek@wpafb.af.mil
2nd TPOC:	Sandra Fries-Carr
Phone:	937-255-4101
Fax:	
Email:	Sandra.Fries-Carr@wpafb.af.mil

OSD06-EP4 TITLE: Oxygen Permeable Membrane for Lithium Air Batteries

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: DDR&E EPTI

OBJECTIVE: Develop a gas permeable membrane with an O2 permeability coefficient of >2000 Barriers with an organic carbonate/ether permeability coefficient of <10 Barriers.

DESCRIPTION: The lithium/air organic electrolyte battery has demonstrated a specific capacity > 500Wh/kg at low rates in pure O2. For low power applications, oxygen from the air could be utilized if a membrane can be developed that allows for oxygen transport but prevents solvents in the organic electrolyte from diffusing out of the cell. A gas permeable membrane with an O2 permeability coefficient of >2000 Barriers and an organic carbonate permeability coefficient of <10 Barriers would allow for the utilization of this chemistry in low power applications and would give a cell with specific energy > 500Wh/kg. The membrane would need to be easily manufactured in a pin hole free format at thicknesses of 25 micron or less. The membrane would need to be stable towards organic solvents, lithium battery electrolytes, and moisture from the air.

PHASE I: The phase I effort should focus on preparing sample membranes and measuring permeability of those membranes to O2 , H2O, and organic solvents such as ethylene glycol dimethyl ether (DME), propylene carbonate (PC), Dioxolane (DOL), and dimethyl carbonate (DMC).

PHASE II: The Phase II effort should focus on scaling up membrane production, producing membrane/electrode assemblies, and building prototype lithium/air cells incorporating the membrane.

PHASE III: The energy storage systems developed here are of great potential value for use in low power applications requiring very light weight and long operational lifetime.

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KEYWORDS: Membrane, Oxygen permeability, Lithium Battery

TPOC: Jeffery Read
Phone: (301) 394-0313
Fax:
Email: jread@arl.army.mil

OSD06-EP5 TITLE: Anode Materials for Rapid Recharge High Energy Density Lithium Ion Batteries

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: DDR&E EPTI

OBJECTIVE: Novel and improved anode materials are being sought that enable high energy density lithium ion batteries capable of being quickly recharged in the field for electronic and small electrical equipment.

DESCRIPTION: Rapid Recharge Battery - The recently developed lithium-ion battery is a safe and reliable power source that has found broad commercial application. Lithium-ion is the highest specific energy of any commercial secondary battery, and converting from primary to rechargeable power sources could substantially reduce the Military's cost for power. The present state of the art carbon negative electrode, however, limits the rate of recharge of the lithium ion battery. At rates higher than C, lithium can be plated on the carbon surface causing a safety hazard. We are seeking new (including nanophase) anode materials that will allow safe and complete recharge of the battery in 15 minutes or less without significant capacity loss for at least 100 deep cycles. Recently published examples of rapid recharge negative electrode materials include nanostructured lithium metal oxides such as lithium titanate. Operation and storage over the full Military temperature range (-40°C to 70°C) is required with minimal degradation and maximal charge retention. Positive electrode materials and electrolytes should be selected to maximize the energy density while permitting the rapid recharge. Successful proposals will include a complete battery chemistry to achieve a battery that can be completely recharged in 15 minutes or less with the least possible sacrifice in energy density from the present state of the art lithium-ion battery.

PHASE I: Phase I should result in the identification/synthesis of at least one new material for a negative electrode and demonstration of complete charge of the new electrode material in 15 minutes or less without deposition of metallic lithium in small laboratory cells or half cells.

PHASE II: Phase II will provide for further exploration and development of all cell components and for the formulation, demonstration and delivery of a complete prototype cell or battery capable of rapid recharge in 15 minutes.

PHASE III DUAL-USE APPLICATIONS: The energy storage components under consideration here are of great potential value for use with cellular phones, laptop computers, camcorders and other commercial electronic equipment.

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KEYWORDS: rapid recharge, anode materials, lithium ion battery

TPOC: Michele Anderson
Phone: (703) 696-1938
Fax: (703) 696-0001
Email: andersom@onr.navy.mil
2nd TPOC: Donald Foster
Phone: 301-394-0312
Fax:
Email: dfoster@arl.army.mil

OSD06-EP6 TITLE: Reduced Temperature, High Power Thermal Battery Chemistry

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: DDR&E EPTI

OBJECTIVE: To develop a new thermal battery chemistry for a thermal battery to be operated at a lower temperature and higher power level.

DESCRIPTION: Currently, the most commonly used chemistry for thermal battery is Li/LiCl-KCl/FeS2, with the Li as the anode, LiCl-KCl mixture as the reserve electrolyte, and FeS2 as the cathode. The LiCl-KCl mixture is of the eutectic ratio; thus, it melts at the lowest possible temperature for the binary system: 352 °C. Of course, the typical internal operating temperature range for thermal batteries in which this chemistry is employed is substantially higher than the eutectic temperature, to ensure that the operation is not hampered by the solidification of the electrolyte, even if it is only regional, and that the electrolyte has sufficient ionic conductivity to support a substantial current passing through the battery. The heat source for melting the electrolyte is supplied by a pyrotechnic material in close proximity to the electrolyte, which when ignited provides the heat and thus activates the battery. Naturally, the higher the temperatures at which a thermal battery operates, the more pyrotechnic material is needed to be packed into the battery, and more severe restrictions are placed on the other materials around the electrolyte and the pyrotechnic material for their compatibility at such high temperatures. In addition, thermal management becomes more challenging as more effort must be devoted to preventing the heat generated in the battery from transferring out too rapidly in order to sustain the operation of the battery and to protect the other components located outside but adjacent to the battery case. Last but not least important, the LiCl-KCl electrolyte is hygroscopic, which necessitates the battery to be hermetically sealed in order to ensure its required shelf life. All these pyrotechnic material, thermal management, and hermetic packaging subtracts from the power efficiency of the thermal battery.

It is thus worthwhile to seek a new chemistry, of which the electrolyte melts at a substantially lower temperature than 352 °C. The electrolyte should also be sufficiently conductive at temperatures above its melting temperature to support a substantial ionic current. It is also highly desirable that the electrolyte be moisture insensitive so that its handling and packaging can be eased. The search of the new chemistry should also include that for a new anode/cathode couple that is more compatible with the new electrolyte if the existing one is not. Foremost on the compatibility list is the 20-year plus shelf-life; that is, the chemistry should remain completely inactive in the range of -50 to 70 °C for over 20 years so as not to decrease the battery capacity during storage. Other compatibility problem spots should also be checked, at both storage and operating temperatures. Successful development of such a new chemistry would result in a thermal battery with greatly improved energy and power or reduced size, and with the required reliability and at lower cost.

PHASE I: This phase is more material-centric, and the major goal is to have a general literature and experimental survey of the more recent materials and chemistries for their suitability to be used for thermal batteries. First, a study needs to be conducted of the existing chemistries and technologies in thermal battery, from which a list of criteria and testing methods is compiled for screening and testing the existing and new chemistries. Then, several new and promising chemistries are studied and tested for possible use as the lower temperature, higher power thermal battery application against the criteria list. Out of the existing and new chemistries, a few chemistries are selected for potential use and for contingencies. Finally, one chemistry is recommended as the new chemistry for lower temperature and higher power thermal batteries. A final report summarizing in detail all the search, screening, study, and testing results, is written which is expected to greatly assist future work in this direction.

PHASE II: This phase will be more device-centric, and specific battery systems and applications will be sought for the use of the new chemistries and materials from the first phase. The new chemistry should be incorporated into prototype, complete thermal batteries, and all the associated compatibility and engineering problems of this new chemistry with the surrounding components are evaluated and resolved.

PHASE III: The technology in which the new chemistry is successfully implemented in new thermal batteries is transferred to a manufacturing company, and thermal batteries utilizing such chemistry begin to be manufactured.

REFERENCES:
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KEYWORDS: Thermal Battery, Chemistry, Electrolyte, Temperature, Conductivity.

TPOC: Michael Ding
Phone: (301) 394-0272
Fax:
Email: michael.ding@us.army.mil
2nd TPOC: Frank Krieger
Phone: 301-394-3115
Fax:
Email: fkrieger@arl.army.mil

OSD06-EP7 TITLE: Robust Silicon Carbide Power Switch Module Technologies

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: DDR&E EPTI

OBJECTIVE: Development of component technologies leading to robust silicon carbide (SiC) power switch modules for use in electrical power generation, control, conversion, and distribution equipment for DoD and commercial applications.

DESCRIPTION: Wide bandgap power devices from materials such as SiC are inherently able to operate at much higher temperatures than silicon devices. Furthermore, higher critical fields (7X) and electron saturation velocity (2X) enable the fabrication of power devices with lower on-resistance and higher switching frequencies, respectively. To utilize the intrinsic high temperature, power, and frequency characteristics of SiC, the need exists to develop suitable switch module component technologies which possess the required electrical and mechanical characteristics. Key focus will be on the demonstration of suitable baseplates/heatsinks, high-strength dielectric potting compounds, robust interconnect metallurgy and techniques, and die attach metallurgy suitable for power switch modules with a reliable operating temperature capability of -40 to 250° C. Wide-range temperature cycling places stringent requirements on matching coefficients of thermal expansion, prevention of package materials degradation, metallurgical compatibility, interconnect reliability, and minimizing thermal impedances between device junctions and module baseplate. Target power device terminal ratings for which this technology will apply are 600 to 1800 volts, and 100 to 1000 amp continuous conduction in current applications. In addition, suitable switch module configurations utilizing these robust technologies will be expected to minimize parasitic impedances to enable switching frequencies of up to 250 kHz, and address heat transport and thermal impedance characteristics to minimize device junction temperatures when operating at 250° C heatsink excursion temperatures. It is anticipated that switch module design will be defined to mean power switch and free-wheeling diode pair configurations in single, dual (phase leg), quad (H-bridge), three-phase inverter or a similar suitable topology. Integrated gate drive functionality is not a requirement for this effort. It is anticipated that a three-phase program would develop SiC power switch modules packaged as hybrid circuits, develop appropriate module drivers or utilize commercial off-the-shelf (COTS) drive circuits when appropriate, and demonstrate the required electrothermalmechanical functionality in an appropriate motor drive, converter, or similar relevant power switching application.

PHASE I: Design and develop SiC-based power switch module technologies capable of operating over the temperature range of -40 to 250° C with the requisite performance characteristics (dielectric, mechanical, thermal, and impedance).

PHASE II: Refine, prototype, and demonstrate SiC switch module capable of meeting performance specifications. Anticipate application demonstration and include performance data over entire temperature range in an appropriate power switching topology (i.e. inverter phase leg, etc.).

DUAL USE COMMERCIALIZATION: Advance power conversion and control technology, by incorporating these modules in actuation, power generation, control and distribution systems for AF, DoD, and commercial applications.

These modules and circuits could be utilized in numerous industrial motor drive, traction drive, medical equipment, generator, and power supply applications. Military applications envisioned for this technology include motor drives, converter, inverter, electric actuation, and other power conditioning and distribution functionality on a wide range of weapon systems and platforms.

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KEYWORDS: silicon carbide, high temperature, power, switch module, hybrid circuits, converter, dielectric, power conversion, power supply

TPOC: James Scofield
Phone: (937) 255-5949
Fax: (937) 656-4781
Email: james.scofield@wpafb.af.mil

OSD06-EP8 TITLE: Advanced 50-kW Thermal Management System Demonstration

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: DDR&E EPTI

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop an advanced thermal management system capable of acquiring, transporting, and rejecting a 50-kW thermal load.

DESCRIPTION: Next-generation, advanced thermal management systems must be capable of acquiring, transporting, and rejecting high thermal loads. Proposed thermal management architectures must conform to rigorous mass and volume constraints requiring the utilization of advanced single-phase and two-phase concepts. These thermal management architectures must also acquire heat from a variety of heat-generating components ranging in temperature from 20 to 30° C to 100 to 200° C with heat fluxes ranging from 100 to 1,000 W/cm². In most cases, there exist multiple heat sources, such as laser and electronic components, requiring cooling at various temperatures. In addition, the thermal management architecture is constrained by the availability of a heat sink to which the thermal load may be rejected. The proposed thermal architecture will be required to interface with a polyalphaolefin (PAO) coolant loop that will reject the thermal load to a 180-m/s ram air heat sink varying in temperature from -40 to 60° C. (The proposed design will also include the liquid/air and liquid/liquid heat exchangers of the PAO coolant loop.) The proposed design will be capable of cooling 20 percent of the total heat load, to a temperature of 100° C at 200 W/cm² and 80 percent, of the total heat load to a temperature of 30° C at 500 W/cm². The thermal system, not including the liquid/air heat exchangers, is limited to a volume less that 75 inches (190 cm) (width) by 38 inches (96 cm) (height) by 120 inches (305 cm) (length). The volume for the liquid/air heat exchangers is limited to 28 inches (71 cm) (width) by 25 inches (64 cm) (height) by 125 inches (318 cm) (length) and is separate, but adjacent to, the remainder of the thermal system. The mass of the proposed thermal management system shall be minimized throughout the proposed technical effort.

PHASE I: Design a thermal management architecture capable of acquiring, transporting, and rejecting a continuous 50-kW thermal load using advanced single-phase and/or two-phase concepts.

PHASE II: Fabricate, demonstrate, and validate a representative, subscale version of the proposed thermal management architecture.

DUAL USE COMMERCIALIZATION: Military applications include a cooling system for a stand-alone aircraft power system for future weapon needs. Commercial applications include a cooling system for any high energy density power systems.

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KEYWORDS: power-conditioning electronics, high-power microwave, laser diode, directed energy, two-phase cooling, boiling, high heat flux, thermal management, harsh environment

TPOC: Joseph Gottschlich
Phone: (937) 255-5734
Fax: (937) 656-7529
Email: joseph.gottschlich@wpafb.af.mil
2nd TPOC: Kirk Yerkes
Phone: (937) 255-6186
Fax: (937) 656-7529
Email: kirk.yerkes@wpafb.af.mil

OSD06-H01 TITLE: Bidirectional Inductive On-body Network (BIONET) for Warfighter Physiological Status Monitoring (WPSM)

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: A bidirectional inductive on-body network (BIONET), envisioned as an essential part of WPSM, is needed to interconnect physio-sensors and processing/data storage nodes on the individual Soldier, and to provide non-RF area-of-care links from the individual Soldier to their squad leader or Medic.

DESCRIPTION: As dictated by physics, this inductive system will have inherently limited range and bandwidth, but also have reduced standoff detectability, decreased power requirements, and increased opportunities for spatial reuse of spectrum. The BIONET is ultimately intended to support the routine ambulatory physiological status monitoring for individual War Fighters in a variety of circumstances including combat.

The goal is to provide a fully-founded technical and engineering path forward without undue use of COTS black- and grey-box chip sets that were not designed for BIONET use. The BIONET system should be designed to readily host moderate- to low-bandwidth WPSM applications. For example, interfacing and support the control of a variety of physiological sensors with distinctly different data rates and information content. The BIONET system must also provide time stamping of data and selected events. Since individual sensors may fail in a variety of modes, or be added and removed from the system over time, the BIONET must be able to reconfigure to accommodate changes in the sensor suite, and must tolerate non-responsive and faulty sensors without undue perturbation to available bandwidth and network latency. In addition, the BIONET should have the ability to support an unlimited number of BIONET users working in close proximity, with a maximum density of one BIONET per square meter. Low detectably at minimum standoff ranges of 10 meters, and resistance to standoff jamming are desirable. Small size, weight and modest power requirements, low procurement cost, >72 hour mission time, and flexible on-body placement of network interface devices is needed. These goals imply an integrated system on chip solution. Wireless elements of the BIONET should be capable of transporting data at an energy cost of 75nJ/bit or less. The conceptual design of the BIONET must include provisions for moving information to a body-worn computer through a standard interface such as RS-232 or USB. Proposed physical and software protocols should be compared and contrasted to evolving industry standards for short-range low-power systems such as IEEE 802.16e.

PHASE I: Phase I effort should define the overall BIONET architecture concept, identify planned use of commercial as well as custom elements, and provide detailed performance predictions for achievable bandwidth, concurrent channels, energy use, and susceptibility to standoff detection and jamming.

PHASE II: Phase II effort will develop five prototype BIONET systems suitable for field trials and performance measurement. The emphasis will be on the sensor interface and data collection and collation elements of the BIONET, with an interface to a body-worn computer. The Phase II effort will include field trials of the BIONET under various working and training conditions to determine the reliability, detectability, energy utilization, and tolerance to the failure of individual sensors. The result of the Phase II effort will be a comprehensive characterization of BIONET performance, and a plan for ruggedization and packaging of the BIONET elements to support operational deployment.

PHASE III: The BIONET will have both military and civilian applications. The advancements in telemedicine technology and Web-based monitoring of home health patients drive needs to remotely and automatically evaluate the clinical condition of patients. These sensing and data collection requirements are typically a subset the capabilities desired for the WPSM. A robust BIONET could also be used to help meet the needs of firefighters and first responders by supporting real-time monitoring of health status in harsh environments.

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2. Final draft ETSI EN 302 291-1 V1.1.1 (2005-05), European Standard (Telecommunications series), Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Close Range Inductive Data Communication equipment operating at 13,56 MHz; Part 1: Technical characteristics and test methods (see http://www.etsi.org)

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KEYWORDS: Ambulatory monitoring, network, inductive, magnetic, wearable sensors, firefighters, first responders

TPOC: Reed W. Hoyt, Ph.D.
Phone: (508) 233-4802
Fax: (508) 233-5298
Email: reed.hoyt@us.army.mil
2nd TPOC: Steve Mullen
Phone: (508) 233-5138
Fax:
Email: stephen.mullen@us.army.mil

OSD06-H02 TITLE: Volume-Sensing Personal Hydration System

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: A novel and practical means of monitoring the volume of fluid in a collapsible bladder-type canteen is needed to help ensure Soldiers stay optimally hydrated and to support tailored water logistics.

DESCRIPTION: The technology being sought to monitor the volume of fluid in a collapsible bladder-type canteen will need to function in the harsh training and operational environments of the dismounted War Fighter. The technology chosen must be simple, reliable, easy to calibrate and operate, low-maintenance, low-power, low-cost, and light-weight. Ideally, sensor elements would not directly contact the fluid being consumed, and be re-usable in a system where the fluid bladder would be disposable. The sensing system must tolerate wide variations in factors such as: (a) orientation, (b) pressurization (due to being compressed by other equipment), (c) fluid composition (electrolyte, mineral, carbohydrates, etc.), and (d) fluid temperature (0 to 50 degrees Centigrade).

The volume sensing approach is distinct from flow sensing in that moving parts will probably not be needed, and the question “how much is in your canteen?” can be answered directly. In contrast, flow meters measure only the fluid volume consumed through a drink tube, while the remaining canteen volume can only be calculated if the initial volume is known. In contrast, a successful bladder canteen volume sensing system will probably not require direct contact with the fluid in the canteen bladder, thus reducing resistance to fluid flow, improving reliability (no jamming), and avoiding the need to clean the sensor. Possible technical approaches to a topic solution include capacitance, inductance, bend sensors, acoustic, and magnetic field strength technologies.

PHASE I: Review the literature to select the most promising methods for developing a canteen volume sensing system with the aforementioned capabilities. Summarize concerns with previous products, outline plans to resolve these problems, and identify key risk factors for project success. Conceptualize and model approach, and demonstrate one or more proof-of-concept prototype system(s), to be used to assess the scientific validity of approach and the human factors acceptability to War Fighters.

PHASE II: Develop five prototype volume sensing systems suitable for field trials and performance measurement. The emphasis will be on the sensor performance and data collection, with the system providing a generic digital data output such as RS-232 or USB. Perform field trials in an appropriate military venue of the volume sensing system under various working and training conditions to determine the reliability, accuracy, acceptability, power consumption, etc., of the system. The exit criteria for the Phase II effort will be a comprehensive characterization of the volume sensing system, with a plan for testing, ruggedization, and production of a Volume-Sensing Hydration System to support operational deployment and commercial use.

PHASE III: The Volume-Sensing Hydration System will have both military and civilian applications. There is an increasing need to chronically monitor the fluid intake of both War Fighters and emergency personnel. However, users of collapsible bladder type systems (e.g., War Fighters, emergency personnel, recreational hikers) typically have no awareness of volume inside their hydration systems. A Volume-Sensing Hydration System would help meet the requirements of many emergency personnel, that is, reliable hydration assurance under harsh conditions while maintaining user acceptability and ease of use. In addition, the volume sensing system could be configured to provide information on the volume of other types of collapsible reservoirs, e.g., monitoring of intra-venous bag volume for medical applications.

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3. United States Patent 6,840,100 Wotiz January 11, 2005 “Liquid level indicator”

KEYWORDS: Warfighter Physiologic Status Monitoring, canteen, ambulatory monitors, wearable, body water, exercise, sweating, personal hydration, firefighters, casualty prevention, first responders, water logistics

TPOC: Reed W. Hoyt, Ph.D.
Phone: (508) 233-4802
Fax: (508) 233-5298
Email: reed.hoyt@us.army.mil
2nd TPOC: Scott J. Montain, Ph.D.
Phone: (508) 233-4564
Fax: (508) 233-5298
Email: scott.montain@us.army.mil

OSD06-H03 TITLE: Integrated Medical and Biosurveillance Early Warning System Technology

TECHNOLOGY AREAS: Information Systems, Biomedical

OBJECTIVE: Investigate and validate fusing open source, medical, and intelligence information to provide commanders with a bioevent decision tool, pre/post event.

DESCRIPTION: U.S. Armed Forces, overseas and at home, face the increasing risk of a bioevent (i.e., an intentional biological agent attack or a naturally occurring outbreak). Bioevent indicators and early warning signs may be provided through the fusion of open source information (i.e. web based engines), intelligence data, and medical surveillance information (i.e. symptoms and trends monitoring, etc.). Together, these disparate information sources may provide commanders with information regarding a possible bioevent before troops or inhabitants of surrounding communities begin to present symptoms. Additionally, should a bioevent occur, commanders must have the necessary tools to identify the event as soon as possible, perform risk assessments, and employ the right consequence management measures. While open source, intelligence and medical surveillance information systems exist and contain pertinent information that may indicate possible bioevents, we seek novel ways to fuse these sources of data into actionable information that allows commanders to make informed decisions regarding the safety of his/her troops before and/or after a bioevent. This includes the discernment of an intentional biological agent attack from a naturally occurring disease outbreak.

PHASE I: Identify innovative concepts and methods for fusing intelligence and medical surveillance data into an information technology system capable of providing decision-makers with early indications and warnings of a possible bioevent. This effort should include identifying pre-event indications and warnings as well as providing post-event consequence management.

PHASE II: Implement the concept and methods from Phase I modeling to design and develop a prototype technology demonstrating the required capabilities. If successful, the product could be rapidly transitioned to deployed troops.

PHASE III DUAL USE APPLICATIONS: This information system will be useful for military applications such as early warning of a bioevent to theater commanders who can then more accurately assess the risk to his/her troops. It will also be useful as a consequence management tool by providing indications of a bioevent as soon as possible after it occurs. Commercially, this system could be used by civilian hospital personnel to prepare in advance for increased patient load should a bioevent occur. Local emergency responders could also benefit from this technology by preparing for and/or managing a bioevent in their jurisdiction.

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KEYWORDS: bioevent, biological agent attack, biosurveillance, consequence management, information fusion, information integration

TPOC: Lt Jennifer R. Plourde
Phone: (937) 255-4903
Fax:
Email: : jennifer.plourde@wpafb.af.mil

OSD06-H04 TITLE: Software to Assess Readiness and Train Medical Support Operations Teams

TECHNOLOGY AREAS: Information Systems, Biomedical

OBJECTIVE: Develop Software Tools to Track, Assess and Train Medical Support Teams for High Performance in Stressful Military or Civilian Operations.

DESCRIPTION: Within the Department of Defense there are numerous contingency plans for many types of operations. But as we have seen in Katrina and in Iraq the plans do not always appear to be dynamically robust. To train people to carry out Medical Support Operations in very dynamic and potentially disastrous conditions it is necessary to build a computer model, or Video Game, that can read in data from real or historical scenarios and adapt the training in real time such that the trainees are stressed at real ops-tempo levels. Such a system needs to be scalable from the Command Staff including the Command Surgeon down to the medics and first aid trained individuals. In Katrina it would have involved the State, Parish, City, FEMA, Military, Coast Guard, NOAA, Corps of Engineers and Federal leaders as well as the police, rescue personnel, medics, nurses and physicians and the communications and logistical support teams. Any such software tool to train medical support operations teams could, in the process, evolve more nearly optimal support operations plans and procedures and finally provide a way of capturing data for lessons learned during real natural or wartime disasters. There are many features that could be incorporated in the computer model depending on its particular use. The following list contains some ideas meant to stimulate to the development of innovative approaches to building the envisioned model and is not meant to proscribe or limit its design or features.

• Create an interactive, adaptive, real world driven computer simulation (video game) to train people carrying out Medical Support Operations.
• Maximize Medical Support Operations performance under stress while dealing with inadequate communication, supplies and support.
• Provide capability to use scenarios from the past or real time evolving scenarios.
• Maintain situational awareness for all in real time – what's happening, what needs to be done where, whom do I call?
• Post requests and actions by functional groups to facilitate Situational Awareness and responsiveness
• Build in real time predictions based on Weather changes and Enemy actions. Include some randomness in the changes.
• Show ongoing validity of predictions – is the model working in near real time?
• Display Logistical Awareness – just in time delivery
• Incorporate "Bird's Eye" review/critique of decisions and progress
• Factor in degradation of action and decisions as time wears on and lack of food and sleep take its toll.
• Automate critique of game and provide suggestions for making better decisions next time.
• Evolve updated Medical Support plans based on training of real people in real time.

It is clear that the ultimate product envisioned would probably not be fully realized with in the scope of this SBIR. But it should be possible to develop a model that incorporates important aspects of training and optimizing medical support team performance in the face of operational stressors.

PHASE I: Identify and define aspects of medical support operations that are sensitive to operational stresses and proposed changes or models that quantify the relationships between stress and performance. Develop and demonstrate a prototype model that integrates models or results of previous research into a more comprehensive model for tracking, training and assessment of medical support operations.

PHASE II: Finalize the design and features of the model from Phase I and validate its performance against atleast one well documented scenario from the literature or against performance in a simulated training exercise or real operational event or natural disaster.

PHASE III: Numerous customers for this model exist within the military, Federal State and Local governments as well as in the civilian industrial area where companies have to develop strategies and train for disasters and coordinate with governmental agencies. The product from Phase II should be immetiately usefull at a level that will garner additional funds for expansion to support a broader market.

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KEYWORDS: Software tools, Assess Readiness, Training, Medical Support Operations

TPOC: Dr. Ted Knox
Phone: (937) 255-0410
Fax: (937) 255-3343
Email: ted.knox@wpafb.af.mil
2nd TPOC: John Plaga
Phone: (937) 255-1166
Fax:
Email: John.Plaga@wpafb.af.mil

OSD06-H05 TITLE: Software Technology for Cancer Epidemiology and Prevention

TECHNOLOGY AREAS: Information Systems, Biomedical

OBJECTIVE: Develop DITSCAP accreditable software that can link and extract person-specific data from cancer registries and personnel databases for epidemiologic and bio-statistical research.

DESCRIPTION: Recent Air Force studies suggest cancer incidence in active duty personnel may differ from that in civilian populations. The reasons and military implications of these findings are unclear.

The Department of Defense maintains several longitudinal databases that can support cancer epidemiology and prevention:

-- Automated Central Tumor Registry.
-- A database of Military Health System cancer patients established in 1986.
-- Contains highly detailed patient-level disease data.

-- Air Force Personnel Center Personnel Database.
-- A database of military personnel.
-- Contains person-level demographic, occupational, aviation, and assignments data.

-- Defense Manpower Data Center Database.
-- A database of military personnel.
-- Contains certain other person-level pre-service, post-service, deployment, and family member data.

A significant hindrance for military cancer studies is the lack of linkages between the disease outcomes database (Automated Central Tumor Registry) and the personnel databases (Air Force Personnel Center Personnel Database and Defense Manpower Data Center Database). Linking stovepiped cancer and relevant personnel data must be done manually, which is extremely cumbersome and time-consuming.
Thus, we propose a small business computer software or programming company develop a technology or application that can link cancer data to personnel data and vice versa. Key features should include the ability to easily select specific data fields and to track persons backwards and forwards in time. This can make a variety of epidemiologic study designs possible and can bolster the quality, depth, robustness, and timeliness of military cancer epidemiology. The analyses should ultimately support more effective and efficient protective measures against cancer. This new software would materially enhance the responsiveness of epidemiologic studies. In the continuing battle to track and understand the incidence and distribution of disease around the world, time is of the essence. New software approaches that speed up the epidemiologic studies are critical to prevent disease.

PHASE I: Analyze and define the critical features of the software application or technology that will support cancer research. Develop approaches for linking the disparate databases, extracting data to form cohorts and for easy use of bio-statistical and epidemiologic tools.

PHASE II: Develop, demonstrate and document the software application or technology. Conduct testing to validate the software to assure data quality and responsiveness. During validation testing, safeguard data according to all applicable military and federal regulations. Propose a commercialization plan.

PHASE III: This software application or technology can be employed in other military and civilian circumstances, where linkages or merging of health outcomes data and exposure data (demographics, occupation, medical services, etc.) are needed.

As such, this product would have a wide military and commercial market.

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KEYWORDS: Tumor registry, cancer, epidemiology, health, medical, surveillance.

TPOC: Col Grover Yamane
Phone: (210) 536-4327
Fax: (210) 536-6841
Email: Grover.Yamane@brooks.af.mil
2nd TPOC: Donald Goodwin
Phone: (210) 536-3471
Fax:
Email: Donald.goodwin@brooks.af.mil

OSD06-H06 TITLE: Software Technology for QFT-GIT ELISA Reader

TECHNOLOGY AREAS: Information Systems, Biomedical

OBJECTIVE: Develop and validate a DITSCAP accreditable computer program to:
1) Provide transformed optical density readings from Triturus Instrument's ELISA reader into clinical results; and,
2) Electronically report the clinical results to the CHCS system for incorporation into the USAF medical record.

DESCRIPTION: The World Health Organization estimates that globally there are 16 million existing cases of tuberculosis (TB) with 8 million new cases each year. TB is caused by Mycobacterium tuberculosis transmitted person to person when an infectious person sneezes or coughs. Upon infection, the host's immune system may contain but not eradicate the TB organism. The result is a latent Mycobacterium tuberculosis infection (LTBI). Without treatment, LTBI may reactivate and become active TB. Military personnel are at risk for TB due to exposures in settings where TB is prevalent. Screening to detect LTBI helps mitigate this risk by enabling early treatment. [1,2]

The Tuberculin Skin Test (TST) has been the primary way of detecting persons with LTBI. A positive TST indicates increased risk of having or developing active TB, but false-positives and false-negatives are common. The largest cause of erroneous TST results is the subjective nature of placement and reading of the test. [2]

On May 2, 2005, the QuantiFERON-TB Gold (QFT-G, Cellestis Limited, Carnegie, Victoria, Australia), was approved by the U.S. Food and Drug Administration as an aid for diagnosing Mycobacterium tuberculosis infection. This test detects the release of interferon-gamma (IFN-g) in fresh heparinized whole blood from sensitized persons when incubated with test reagent antigens. These reagent antigens impart greater specificity than is possible with the TST, [3,4,5] however, because of practical limitations, few agencies have adopted the QFT-G test.

Cellestis has since refined the QFT-G test and produced the QFT-GIT test. This refinement has made the QFT-GIT test practical for mass screening purposes. Unlike the TST, the QFT-GIT test requires only a single patient visit and is expected to produce more reliable results. In preliminary studies, the QFT-GIT test has been found to have greater specificity than the TST with 33 to 78% fewer positive results in cohorts with increased risk or minimal risk, respectively.

A trial has been proposed to assess the comparative performance of the QFT-GIT test relative to the TST for detecting LTBI during TB screenings among USAF Basic Military Trainees. The QFT-GIT trial will also enable an assessment of an automated ELISA reader (Triturus Instrument) which has the capacity to significantly reduce the manpower and time requirements for processing mass serological screening tests which require an ELISA reader. However, the Triturus Instrument has not been used before with the QFT-GIT test or by the USAF for any ELISA test.

The Triturus Instrument will have to be able to transform its optical density output readings into clinically relevant results – "positive", "negative", or "indeterminant". This will require software which includes that enables incorporation of optical density readings from both positive and negative controls into the interpretation of the optical density reading for the test specimen. Once an interpretable clinical result is produced, the software will need to direct those results to the USAF medical record. This will require development of a Triturus/CHCS interface software that is to be developed in conjunction with CHCS and the USAF medical records system

PHASE I: Develop a technology or software application that can transform the Triturus Instrument's ELISA readings into clinically interpretable results and them feed those into the USAF medical record (CHCS system). Key features should include the ability to consider the control samples as well as the clinical specimen in the determinations of test results.

PHASE II: Validate the software for accuracy and consistency within the context of a clinical trial of the QFT-GIT test and the Triturus Instrument (ELISA reader) and publish the statistical analysis of the test and the reader. Deliver the validated and documented software.

PHASE III: This software will enable an automated method for processing and reading the QFT-GIT test results. The QFT-GIT test is anticipated to be the replacement for the problematic TST test for routine screening for evidence of latent TB infection among USAF/DoD personnel.This effort should result in enabling a new defacto standard for TB testing with worldwide application in military and civilian sectors.

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KEYWORDS: QuantiFERON, QFT-GIT, Mycobacterium tuberculosis, Tuberculin Skin Test, TST

TPOC: Dr. Donald Goodwin
Phone: (210) 536-6030
Fax: (210) 536-6841
Email: Donald.Goodwin@brooks.af.mil
2nd TPOC: Dr. Gerry Mazurek
Phone: (404) 639-8174
Fax: (404) 639-8961
Email: gym6@cdc.gov

OSD06-H07 TITLE: Computerized Impact Injury Risk Assessment Tool

TECHNOLOGY AREAS: Information Systems, Biomedical

OBJECTIVE: Web-based tool to provide field commanders with the ability to conduct assessments of impact injury risk to military personnel.

DESCRIPTION: A wide range of methods, including biodynamic models and impact injury criteria are publicly available to estimate the probability of human head, spinal, and soft tissue injury as experienced during abrupt deceleration/acceleration, crashes, blasts, and contact with blunt objects or surfaces. These include NHTSA's Nij Neck (Nij) and Thoracic Injury Criteria, Mertz Hybrid III Injury Threshold, Air Force DRI/MDRC lumped parameter models, ASCC Neck Injury Limits, JHMCS Neck Injury Criteria, Head Injury Criteria (HIC), Gadd Severity Index, Maximal Strain Criteria (MSC), ATB & MADYMO computer models, and AIS/ISS injury scales. Use of these methods for injury prediction currently require experts to specify the appropriate groups of individuals and environmental parameters, collect and input specific biodynamic response and anthropometric data, and then conduct a detailed and time-consumming analysis. However, in planning for battlefield missions with the potential for vehicle crashes, blasts, and other impact events, field commanders should also have the necessary tools to quickly and accurately assess the probability and severity of potential injuries caused by these impact events. This would enable them to employ injury risk management measures prior to conducting the mission, and allow them to make informed decisions regarding troop safety versus mission benefit when assessing risk during crashes and impacts of military vehicles, including airplanes, helicopters, boats, and ground transport vehicles. AFRL/HEP has successfully developed a similar web-based tool called the Altitude Decompression Sickness Risk Assessment Computer (ADRAC) model that is currently being used by Air Force Special Operations commanders to estimate the risk of high-altitude decompression sickness during high-altitude missions.

PHASE I: Identify validated impact injury criteria and models capable of predicting the severity and probability of impact injury during military vehicle crashes, blasts, and aircraft ejections. Develop a computer demonstation that can show the feasibility of conducting impact injury risk assessments in the field using these criteria and models, based on a set of pre-defined user inputs.

PHASE II: Implement the concept and methods from Phase I to develop a complete prototype web-based impact injury prediction tool. The tool should be capable of searching and identifying relevent validated injury criteria and models, and generating probability of injury curves based on sets of input parameters from users employing personnel in military vehicles.

PHASE III: If successful, this injury prediction tool will be useful for military planners and by giving field commanders the ability to assess the potential injury risk to military personnel during a wide range of potential mishaps in different types of vehicles, such as helicopters and ground transport vehicles. Theater commanders can then more accurately assess their overall mission risk and potential troop injuries prior to actual troop deployments. Commercially, this tool could be used by civilian personnel in motor sports and rescue vehicles to assess the risk versus benefit of operating vehicles at various speeds and conditions. AFRL/HEP has developed experimental sensors used to instrument race car drivers and boxers, as well as ejection and blast models and a comprehensive data bank that could aid in both product development and commercialization.

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KEYWORDS: injury criteria, injury prediction, biomechanics models, impact acceleration, impact injury, blast injury

TPOC: John Buhrman
Phone: (937) 255-3121
Fax: (937) 255-3343
Email: john.buhrman@wpafb.af.mil
2nd TPOC: John Plaga
Phone: 937-255-1166
Fax:
Email: john.plaga@wpafb.af.mil

OSD06-H08 TITLE: Global Profile Database to Blood Donor's identity, Health,Travel History

TECHNOLOGY AREAS: Information Systems, Biomedical

OBJECTIVE: Develop a Global Software System for Blood Donor Identity, Deferrals, Health and Travel History for Safety of Global Blood Supply.

DESCRIPTION: The Food and Drug Administration (FDA) is the responsible agency for ensuring the safety our nation's blood supply. The Center for Biological Evaluation and Research (CBER) is in charge of regulating the collection of blood and blood components used for blood transfusions or for the manufacturing of pharmaceuticals that are derived from blood components, like clotting factors. CBER is also responsible for establishing standards for these products, and works closely with the Public Health Service (PHS) for identifying potential errors or threats to blood safety through developing adequate technical standards to implement zero risk transmission of infectious disease.

Above all, over the years the Food and Drug Administration (FDA) has tightened the safeguard rules in order to protect the patients against the unsafe and unsuitable blood and blood products. Because of the FDA tight mandatory regulations, blood donors are asked very specific and direct questions about multiple risk factors and the answers must be carefully documented and filed appropriately.

Donor Screening and Deferral process includes:

- Education.
- Demographics.
- Health History.
- Physical Examination.
- Civilian Travel Data.
- Department of Defense (DoD) Travel Data.

The Armed Services Blood Program (ASBP) provides quality blood products and services that are suitable for all worldwide customers in peace and war. The ASBP vision is to be a preeminent quality, cost effective blood system providing blood products, blood substitutes, and services wherever and whenever needed. Every year, patients in military medical treatment facilities receive more than 54,000 units of red blood cells, 20,000 units of plasma and 5,000 units of platelets. Thousands of blood products have been transfused to injured personnel serving in Iraq and Afghanistan alone.

All blood bank facilities keep individual files that correspond to a particular time of donation and when the same donor is reevaluated for next blood donation eligibility a new file is created and data is filed separately. There is no system to evaluate the continuity of donor's data with multiple blood donations over the time. Because each questionnaire is based on verbal consent, donors are taken for granted when asked personal risk behavior or travel questions. A discrepancy in donor's data base can occur for example when a donor does not remember each time the exact number of weeks that traveled oversees which can lead to a permanent deferral. When FDA inspector shows up ad hoc, one of the immediate questions is about the available access to the blood donor's data files. For donors that donated multiple times, all travel answers to questions from screening and deferral files must match perfectly.

PHASE I: Develop a global profile software technology to provide universal access to donor identity, previous deferrals, and travel history to assist data filing continuity of the blood bank collection facilities. This software should allow the user to:

1. Identify and protect the correct donor's identity
2. Previous donations data access
3. Temporary or permanent deferrals
4. Oversees travel history that can be updated and verified with each blood donation

PHASE II: Validate the software from Phase I in multiple clinical settings to ensure that it is robust, gives accurate, consistent answers, has a user interface that can be used worldwide and is secure. To the greatest extent possible data input should be automatic and in real time with real time checks for accuracy and consistancy. Routine backup and security are parmount.

PHASE III: These ground breaking improvements in data management will quantitatively improve the utility and safety of the nation's blood supply. It will become the model for the World Health Organization practice and could be utilized world wide thereby ensuring safe access to blood products for the traveling military and public.

Such a secure robust medical data system should also be a model for tracking of invectous disease and accident data by Centers for Disease Control and National Highway Transportation Safety Administration and their worldwide partners.

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4. http://www.hhs.gov/pharmacy/pp/DHHSpresent/

KEYWORDS: Blood supply, questionnaire, donor screening and deferral, eligibility, global database, blood safety, data continuity

TPOC: Maj Ileana Hauge
Phone: (937) 255-0443
Fax:
Email: Ileana.Hauge@wpafb.af.mil

OSD06-H09 TITLE: Natural Language Processing

TECHNOLOGY AREAS: Information Systems, Biomedical

OBJECTIVE: Design and develop a natural language processing engine that is compatible with Armed Forced Health Longitudinal Technology Application(AHLTA-DoD EHR) and is linked to MEDCIN, UMLS and SNO-MED CT ontologies. The goal is to be able to process semi-structured or free text note sections of AHLTA and be able to capture both contextual and structured terms for surveillance and data mining. The tool must show how these captured structured terms can be extracted and searched from the clinical data repository.

DESCRIPTION: The task is to design and develop a natural language processing engine which can be used to allow providers to document their care in the electronic health record in a natural way, without forcing them to use structured documentation. Currently, much of the documentation is "too structured", forcing providers to use a very hierarchical structure of MEDCIN. There is significant evidence that this method causes significant errors and the result is a documented note which does not accurately capture the essence of the patient encounter.

The tool must work within the AHLTA construct to improve how we can improve documentation care. What is needed is a natural language processing engine that allows providers to document the encounter as they would normally in AHLTA (mostly free text in "subjective & objective" portions of an encounter) but be able to structure the information in a way that can be mined for surveillance, decision support or data mining.

The tool should work within the construct of DoD Terminology Service Bureau and be compatible with its ontologies (mainly SNO-MED CT). It will work as the note is being created or after it is submitted and correctly capture 90% of the key terms identified by an independent panel of physicians in any given specialty.

The tool should also work with available commercial speech technologies to allow terms to be directly linked to established ontologies.

PHASE I: Formulate technical and operational concepts, a research strategy and design a prototype natural language processing engine that is compatible with Armed Forced Health Longitudinal Technology Application(AHLTA-DoD EHR) and is linked to MEDCIN, UMLS and SNO-MED CT ontologies. Perform Market Analysis of natural language processing engine[s]. Then develop an approach to capture 70% of the key concepts of the AHLTA note (subjective and objective section) of 100 randomly selected primary care note[s]. The key concepts will be determined by an independent group of primary care providers. The awardee will obtain the necessary ontologies to include SNOMED CT.

PHASE II: Develop, test and demonstrate a prototype natural language processing engine that is compatible with Armed Forced Health Longitudinal Technology Application(AHLTA-DoD EHR) and is linked to MEDCIN, UMLS and SNO-MED CT ontologies. Refine a natural language processing prototype, which will interface directly with AHLTA. The tool must receive the data directly from our DoD electronic health record and result the key terms as output to clinical data repository through the terminology service bureau. Lastly it must be compatible with free text or commercially available speech recognition technologies. The tool must be a fully integrated tool which will process the data (both semi structured and free text) and be able to tag the key terms either during documentation or after they are submitted. The tool must have an embedded quality control process. For dications, it must be able to deliver the document in a CDA-R2 standard. It must be able to capture at least 90% of the key concepts, determined by the independent panel. Lastly, the tool must show how the extracted terms can be searched from the Clinical data repository. In this phase, tool must be made with open archictecture to be compatible with other electronic health records in the commercial sector. An interface document will be produced to allow this tool to be integrated with other electronic health record.

PHASE III: Assist the DOD(HA) PEO IM/IT in transitioning this technology to the Military Health System TRICARE medical information technology programs including the DOD electronic health information system, AHLTA. Develop and execute a commercialization and marketing strategy for transitioning this technology to the civilian health care and health care information systems industries. This phase begins with a) release of a production product NLP engine for any healthcare electronic health records b) validating the accuracy of the NLP structured data extraction in electronic health record. The ultimate goal is to develop a tool which can be used to improve structured data content without forcing providers or users to use structured documentation. Specific examples are in areas of data mining, medical surveillance, and electronic health record. Extend the capability to include MHS and VA Health System beneficiaries. Market the capability to developers and vendors of civilian health information systems and to civilian health care providers that see Military Health System beneficiaries under one of the TRICARE Management Activity health care plans.

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Prepared By: Integic, a Northrop Grumman Company

KEYWORDS: Natural Language Processing, Electronic Health Record, Electronic Medical Record, Structured Data

TPOC: Hon S. Pak
Phone: (301) 619-7923
Fax: (301) 619-7968
Email: pak@tatrc.org

OSD06-H10 TITLE: Civilian Medical Records Interface tool for AHLTA and VISTA

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: ASD(HA) PEO IM/IT

OBJECTIVE: Design and develop an interface tool for transferring digital or typed medical records from diverse commercial or government medical information systems to the DOD Military Health System (MHS) Armed Forces Health Longitudinal Technology Application (AHLTA) and Veterans Administration Veterans Health Information Systems & Technology Architecture (VISTA) medical information systems.

DESCRIPTION: The task is to design and develop an interface tool for transferring digital or typed medical records from diverse commercial or government medical information systems to the DOD Military Health System (MHS) Armed Forces Health Longitudinal Technology Application (AHLTA) and Veterans Administration Veterans Health Information Systems & Technology Architecture (VISTA) medical information systems. Within the DOD Military Health System, efforts have been underway for several years to change over to fully digital health care records. While these efforts are nearing fruition via the advent of the MHS AHLTA system and impending interface between the AHLTA and VA VISTA systems, the DOD is still unable to rapidly incorporate medical records or records of clinical encounters or hospital visits by MHS beneficiaries to civilian or other government health care providers. This includes the vast network of civilian providers funded by the DOD TRICARE Management Activity (TMA) under any of the three TRICARE programs: TRICARE Prime, TRICARE Extra, or TRICARE Standard. At the current state of AHLTA implementation, even if medical records on TRICARE beneficiaries from TRICARE providers were made available to the MHS, they could not be incorporated into VISTA without significant manual interpretation and data input. What is needed is a digital and typed health information record interface tool designed so that developers and vendors of civilian medical information systems can easily develop and provide an interface capability for their system that generates digital outputs that can be directly input into either the DOD AHLTA or VA VISTA medical informations without further translation of medical terminology or clinical data by either users of the civilian system, the MHS users of AHLTA, or the Va users of VISTA. The same tool should be capable of being used with an optical character reader so that typed civilian medical records can also be scanned and translated to digital outputs that can be directly input into AHLTA or VISTA without further processing. Several medical terminology tools and resources have been developed that should be useful in this effort. They include the National Library of Medicine's Unified Medical Language System (UMLS), the Systematized Nomenclature of Medicine-Clinical Terms (SNOMED-CT) and a commercial tool called MEDCIN by Medicomp Systems Inc. Additional natural language processing technology or research may be needed to provide accurate codable interpretations of narrative notes and summaries. Image-based medical records such as X-rays, anatomical photographs, and ECG charts should also be included in the digital medical record for future transfer to AHLTA and current transfer to VISTA. Medical data should be stored in a format that is compatible with both the military health system data standards and internationally accepted medical data standards such as Health Level Seven (HL-7), Extended Markup Language (XML), and Digital Imaging and Communications in Medicine (DICOM). In order to adequately data mine medical histories the medical data and textual narrative summaries, diagnoses, notes, orders, and procedures should be mapped (coded) to the International Classification of Diseases, 9th and 10th editions (ICD-9/10) and Current Procedure Terminology, 4th edition (CPT-4) Coding schemes for medical findings and diagnoses. The Medical data should be secured in accordance with the Health Insurance Portability and Accountability Act of 1996 (HIPAA)

PHASE I: Conduct appropriate research to develop a concept and design for a tool which can be easily used by developers of civilian health care information systems to provide an automated capability for users of their commercial health information systems to transfer digital or typed medical records from diverse commercial or government medical information systems to the DOD Military Health System (MHS) Armed Forces Health Longitudinal Technology Application (AHLTA) and Veterans Administration Veterans Health Information Systems & Technology Architecture (VISTA) medical information systems. The objective of this SBIR topic presents a broad challenge in several different areas of information processing technology. Because of the limited scope of an SBIR, proposers may choose to focus on only one or two of the challenges discussed above.

Proposers must identify within their Phase I proposals, all Phase II requirements for deidentified examples of health care data from the DOD AHLTA or VA VISTA systems. No research data will be provided by the government during Phase I. All Phase I awardees will be required to complete all security, privacy, research protocol and data use agreements during Phase I in order to obtain AHLTA or VISTA research data for Phase II. Such documention must be included in the Phase II proposals. Examples of required data use agreements, research protocols, and security and privacy certifications as well as data dictiionaries for AHLTA and VISTA will be provided by the COR to Phase I awardees at the Phase I kickoff meeting.

PHASE II: Develop, test and demonstrate a prototype tool which can used by developers and vendors of civilian health care information systems to provide an automated capability to users of their commercial health information systems to transfer digital or typed medical records from diverse commercial or government medical information systems to the DOD Military Health System (MHS) Armed Forces Health Longitudinal Technology Application (AHLTA) and Veterans Administration Veterans Health Information Systems & Technology Architecture (VISTA) medical information systems. Implement the system for operational testing within the DOD Military Health System (MHS) or a test database of the DOD MHS AHLTA and VA VISTA.

PHASE III: Implement and operationally test the tool capability for developers and vendors of commercial health information systems to automate transfer of digital or typed medical records from diverse commercial or government medical information systems to the DOD Military Health System (MHS) Armed Forces Health Longitudinal Technology Application (AHLTA) and Veterans Administration Veterans Health Information Systems & Technology Architecture (VISTA) medical information systems. Extend the capability to include military dependents and other MHS and VA Health System beneficiaries. Market the capability to developers and vendors of civilian health information systems and to civilian health care providers that see Military Health System beneficiaries under one of the TRICARE Management Activity health care plans.

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2. http://www.hl7.org/ (HL7 Standards & background)

3. http://medical.nema.org/ (DICOM Standards & background)

4. http://aspe.hhs.gov/admnsimp/faqcode.htm (ICD-9/10 and CPT-4)

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http://www.tricare.osd.mil/ais/default.htm
http://www.tricare.osd.mil/policy/tma02pol.htm
http://www.tricare.osd.mil/imtr/jcaho/hpjcaho2.html
http://www.ha.osd.mil/AHLTA/
http://www.defenselink.mil/releases/2005/nr20051121-5122.html
http://www.ha.osd.mil/ahlta/default.cfm
http://www.vista-office.org/
http://www.va.gov/vdl/
http://www.snomed.org/
http://www.nlm.nih.gov/research/umls/
http://www.nlm.nih.gov/research/umls/Snomed/snomed_main.html
http://www.connectingforhealth.nhs.uk/technical/standards/snomed
The Military Health System (MHS) is essentially a giant HMO operated by the Military services and the DOD TRICARE Management Activity (TMA) to provide both peacetime health care and deployed combat support health care for beneficiaries deemed eligible by the Secretary of Defense. For new information about the updated TRICARE web site and links to other site which may help: http://www.tricare.osd.mil/
M2 data specs may be found at:
http://www.tricare.osd.mil/hpae/functionalspecs.cfm

6. Clinical Data Mart data specs may be found at:
https://eids.ha.osd.mil/cdwdocs

7. AHLTA web site:
http://www.tricare.osd.mil/peo/citpo/chcsii.htm

8. DOD TRICARE Medical Records privacy and security (including digital records):
http://www.tricare.osd.mil/TMAPrivacy/default.cfm

9. A summary of DOD/VA separation physical functional integration policy:
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10. DOD AHLTA – VA VISTA Strategic Direction:
http://www.govhealthit.com/article91517-11-21-05-Web

KEYWORDS: medical terminology. Medical information systems, clinical information systems, electronic medical records, UMLS, SNOMED-CT, AHLTA, VISTA, XML, DICOM, HL-7

TPOC:	Gary R Gilbert
Phone:	(301) 619-4043
Fax:	(301) 619-2518
Email:	gilbert@tatrc.org

2nd TPOC: Hon S. Pak
Phone: (301) 619-7923
Fax: (301) 619-7968
Email: pak@tatrc.org

OSD06-H11 TITLE: Simulation-based Planning and Training Tool for Infectious Disease Outbreak, i.e., Pandemic Influenza

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To develop a PC-based simulation tool to support military and civilian Medical Treatment Facility (MTF) planning and training for non-combat related infectious disease outbreaks, e.g., pandemic influenza. During a pandemic, MTFs would be a focal point for infectious disease yet would still have to provide services for non-infected individuals. MTFs must be able to plan for, and predict the consequences of, outbreaks so they can treat infected and non-infected patients, including those requiring emergency treatment, without exposing non-infected patients to infectious disease. Planning requires careful consideration of how to handle both exposed staff and patients and coping with the anticipated surge of exposed/infected patients and "worried well" among other issues. This solicitation requires a system that allows staff to model and simulate alternative responses to an infectious disease outbreak in their medical facilities and to design strategies that minimize risks to noninfected patients and to medical staff.

DESCRIPTION: Generally, we are looking for innovative ideas that explore and harness the power of interactive multimedia computer game technologies such as avatar worlds, e.g. "sim games", that offer single or multi-player interaction via single computer, network or internet in simulated "virtual" scenarios / worlds. User(s) could be presented with single or multiple challenges in scenarios that allow participation in, and response to, pandemic influenza events. Advanced distributed learning & simulation-based training as part of a coordinated disease surveillance plan, should enable health-care personnel to plan, respond and manage infectious disease outbreaks (pandemic, noro-virus, tropical diseases etc) in hospital/MTF settings. Tools that can be extended for use by the general military population for proactive preventive medicine are desirable. Tools should be based on existing medical and allied health knowledge, should be universally accessible and should allow for unlimited practice. We seek a tool with the following features:

1. Designed in the "simulation / strategy game" genre and NOT "first-person shooter" genre.
2. Scenario editor to develop / change scenario variables such as patient numbers, arrival patterns, and patient risk levels, e.g., high-risk, low-risk, facility configuration, major equipment and supply items, and health care personnel staffing patterns.
3. Simulation will allow staff to test various response strategies, e.g., quarantine, separate facilities for infected and noninfected patients and staff, etc., and to identify and analyze vulnerable points in those strategies, e.g., congregations in dining hall, meeting facilities, parking lot, etc.
4. Embedded metrics that identify the consequences of implementing various strategies, e.g., management of time, equipment and supplies, clinical and support staff, medical treatment facility, and provide performac feedback to the user.
5. PC-based (desktop &/or laptop) with an intuitive videogame interface that would give planners a top down, dynamic, graphical view of patient and staff flow in a medical facility.
6. Built using open source software architectures.
7. Compliant with Shareable Content Object Reference Model (SCORM) standards. (http://www.adlnet.org/).
8. DESIRED but not an absolute requirement - allows the user to simulate integration of local, state and national response efforts so that, in the game, a user has to respond / adapt to changes that occur at higher levels, e.g., quarantines that impact travel, commerce, access to supplies, etc.
9. DESIRED but not absolute requirement - explores the use of "intelligent tutoring" capability to take advantage of "teachable moments" for delivery of relevant curriculum.
10. DESIRED but not absolute requirement - includes an editing tool to allow planners to create an approximation of their own medical facilities.

PHASE I: Development of a complete concept plan and a design for a prototype system to teach skills required by military and civilian medical treatment facilities who may respond to pandemic influenza outbreak, and provide a working demonstration of the concept. In the concept plan, address the following items with respect to the Phase II requirements:
1. Describe and illustrate tool(s) under consideration.
2. Model the proposed system configuration with respect to listed requirements.

PHASE II:
1. Build and demonstrate the prototype system.
2. Embed metrics for performance assessment.
3. Validate system performance with subject matter experts.

PHASE III: This capability will provide an immediate, increased capability throughout military and civilian Medical Treatment Facilities.

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KEYWORDS: medical simulation, pandemic influenza, open source, simulation strategy game, advanced distributive learning, medical skills training, metrics, virtual worlds, avatar, intelligent tutor

TPOC:	CDR Russell Shilling
Phone:	(703) 696-4502
Fax:	(202) 767-3172
Email:	russell.shilling@nrl.navy.mil
2nd TPOC:	Mr. Harvey Magee
Phone:	(301) 619-4002
Fax:	(301) 619-7911
Email:	magee@tatrc.org

OSD06-H12 TITLE: Multimedia Combat Injury Management Training

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To prepare a proof-of-concept, design, develop, build and demonstrate a computer-based, media-enabled training system that will deliver didactic training in life-saving resuscitative, procedural, and surgical patient management for the complex battlefield injuries, including those caused by explosions and improvised explosive devices. Since most medical professionals have limited practical experience in the application of their skills to an austere environment, this training will be practical for military and civilian health care professionals (i.e., physicians and Special Forces medics, as well as allied, non-governmental organization and foreign national healthcare professionals) and may have substantial implications for the Centers for Disease Control and homeland defense markets.

DESCRIPTION: Army, Air Force, and Navy medical personnel perform the primary assessment and treatment of personnel with injury, including those with life threatening wounds from blast and fragmentation. The training system produced should promote acquisition and maintenance of skills in trauma resuscitation and trauma surgery -- methodologies and techniques used by surgeons in Level 2b and Level 3 medical facilities of USCENTCOM. It will provide a level of training not possible using traditional and mannequin-based training methods currently in use. Furthermore, the training system should be developed to complement current predeployment training platforms such as the Joint Forces Combat Trauma Management Course, a training module built upon contemporary lessons learned, emphasizing broad training aims and mission adaptability.

The training system should be based on video recording of the actual treatment of severe injuries, including explosive injuries, in deployed Level 3 facilities. Of particular interest are technologies and techniques that present the user with multiple patient conditions and complications (e.g., shock, hypothermia, coagulopathy, etc.) that might be encountered during the management of complex battlefield trauma. Key elements of a successful project are, as follows: 1) training script development; 2) technology assessment; 3) multimedia-enabled training content production; and 4) SCORM19-compliant software development. These key elements should be accomplished in coordination with US military surgeons, the Command group at the US Army Institute of Surgical Research (USAISR), and the Office of The Army Surgeon General. USAISR will serve as the liaison to USCENTCOM and other relevant operational Commands.

For a successful Phase 1 effort, the awardee will develop a collaborative team (e.g., subject matter experts), define educational needs and target audience, understand logistical constraints of patient care environment, review existing peer-reviewed literature (e.g., resuscitation, hemorrhage control, damage control surgery, explosive injury), review and identify educational technologies (e.g., motion sensors, 3D, modeling), and define the scope of the Phase 2 project. Attributes of a successful training system proposal will be, as follows: a) trauma treatment training and casualty management techniques should be based on clinical protocols developed and accepted by US military combat surgeons; b) cases and management should be based on embedded metrics for performance assessment and training; c) user interface should contain a module that allows the teaching, rehearsal, testing and results tracking of the user; and d) didactic content should include a SCORM-compliant browser-based didactic curriculum.

It is anticipated that a successful Phase 2 project will a produce a computer-based, media-enabled training system of relevant educational technologies (e.g., 3-D modeling, animation, motion sensors, force-feedback devices, interactive game formats), create multimedia educational content consistent with a Government-approved storyline/ curriculum, and assimilate content and technologies onto a PC/DVD platform.

PHASE I: Phase I will develop a feasibility concept and plan for developing and /or applying various innovative simulation technologies to the performance of trauma resuscitation, treatment and patient management post-surgery. Development performance objectives listed in the topic description should be addressed. In addition, requests for relevant permissions for access to military facilities in the USCENTCOM area of operations should be initiated, and detailed planning should be initiated for Institutional Review Board approvals (e.g., compliance with DoD Directive 3216.2 and 32 CFR219) and for ensuring compliance with PL 104-191, Health Insurance Portability and Accountability Act (HIPAA) of 1996.

PHASE II: This effort will develop a computer-centered, media-enabled intelligent tutoring system that teaches medical personnel approaches to trauma management (see Description for details of expectations and performance goals). The course will be tied to DoD training standards and be SCORM-compliant to support Advanced Distributed Learning.

PHASE III: The focus will be on commercializing a training system for both military and civilian environments. The training system should permit expansion to other military and civilian-relevant trauma management procedures. In the future the system should be capable of allowing providers to train for patient-specific cases (e.g. utilizing diagnostic imaging data from patients).

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KEYWORDS: Advanced distributed learning, medical protocols, telemedicine, medical training, intelligent training systems, procedural training, field surgery, combat casualty care, trauma, injury, military medicine, combat wound, blast injury, fragment injury, improvised explosive device, medical skill acquisition, predeployment training, multimedia, battlefield, medical simulation, metrics.

TPOC: COL Brian Eastridge
Phone: 210-916-7104
Fax:
Email: brian.eastridge@amedd.army.mil

OSD06-IA1 TITLE: Cross Platform Digital Rights Management

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: A Cross Platform Digital Rights Management (CP-DRM) provides a data owner with the ability to control the flow of sensitive digital information even after it has been released. Original Classifying Authorities (OCA) would have options on how to protect their digital information as well as have the ability to track the material when distributed by the receiver.

DESCRIPTION: Controls are needed to enforce protection of sensitive digital information even after the information is released to another party. A cross platform, non-intrusive digital rights management technology can achieve this end with minimal restriction of receiver rights. Therefore, the CP-DRM needs to make the protection element together with the data a self-contained package that will not modify any software or configuration on the receiving system. The technology needs the ability to completely purge the given data from the system without any adverse effect on the rest of the hardware and software. Protection options would range from permission to print, copy, or transfer the information, as well as the number of times to do each. The data owner will also need the ability to set a “time to live” of the data for eventual public release or for self-purge of the data on the receiving system. Finally, the CP-DRM needs to track distribution of the data after initial release, and document modifications to the original.

PHASE I: Perform a study of methods to implement a non-intrusive, platform-independent Digital Rights Management technology.

PHASE II: Design and architecture requirements documents will be written with emphasis on inter-platform information flow, non-intrusive data protection and sanitization, and auditing of second-hand distribution/modification. A prototype/Engineering Development Model (EDM) would be developed on laboratory systems to demonstrate the feasibility of the design.

PHASE III DUAL USE APPLICATIONS: The final phase would entail the productization of the Cross Platform Digital Rights Management technology for use by the military, homeland security, and the commercial world. The military would use the CP-DRM to protect and track distribution of sensitive and classified material. Commercial sectors can utilize this technology to assure protection of copyrighted material while not interfering with private property rights of the buyer (e.g. music and movie companies).

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KEYWORDS: Digital Rights Management, Cross Platform, Non-Intrusive

TPOC: Kerry Wong
Phone: 732-427-2558
Fax: 732-427-2062
Email: Kerry.Wong@us.army.mil
2nd TPOC: Len Pohl
Phone: 732-427-3724
Fax:
Email: len.pohl@us.army.mil

OSD06-IA2 TITLE: Artificial Intelligence Technique Applied to Cross-Domain Solution

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Perform research into developing a system that applies one or more method(s) of artificial intelligence (AI) to provide assured sanitization in a Cross-Domain Solution (CDS) (there is a dearth of AI applications in this area). The proposed design should implement a recognized AI technique or application such as machine learning, pattern recognition, knowledge representation, natural language processing, language translation, an expert system, or an agent-based approach. Any other AI method may be considered. Large memory techniques, such as Trados can also be investigated. The focus of the effort should be on realizing a high level of assurance for information passing between security levels, especially information that would fail security requirements in a typical CDS.

DESCRIPTION: With the increase of digitization on the battlefield information of many different security classification levels and categories (i.e. unclassified sensitive, US Secret, NATO Secret, Top Secret, etc.) is available. The challenge is to be able to:
· Receive and store data of different classifications
· Keep the data of different classification levels separate; prevent the data of different classifications from mixing
· Allow access of data to users at the lower classification level in a useful form
· Allow sharing of data from lower to higher security classification without allowing access to higher classification data or networks
· Allow users access only to data that their individual clearance allows

Most importantly, do this in a timely and automated fashion and in a secure manner. Successful completion of this SBIR topic would significantly aid in meeting these challenges.

Similarly, information crossing levels of security may be improperly sanitized by a CDS that lacks intelligence of the data traffic. An AI solution could prevent mistakes of this sort.

PHASE I: Research possible approaches for AI towards DOD Multi-Level Security Policy. A set of alternatives would then be presented to the government. The contractor and the government would make a joint decision on the most promising techniques to pursue in Phase II.

PHASE II: The most promising techniques emerging from the Phase I effort would be further developed and modeled. A performance description or specification would be developed. A prototypical working software model will be delivered for demonstration.

PHASE III: Military use would include a DOD Cross-Domain Solution that effectively implements a method(s) of artificial intelligence, used by soldiers who are assigned to work in multi-level security environments. Commercial uses would include a similar system in multi-level environments outside the DOD - in such diverse industries as banking, electric power utilities, telephone systems, police and emergency civilian personnel, etc.

REFERENCES:
1. http://iase.disa.mil/cds.index.html - Cross-Domain Solutions

2. http://en.wikipedia.org/wiki/Artificial_intelligence - Summarized AI methods

3. http://www.aaai.org/AITopics/html/military.html - AI / Military

KEYWORDS: Artificial Intelligence, Expert System, Intelligent Agent, Cross-Domain Solutions, Multi-level Security, Security Policy

TPOC: Derek Scherer
Phone: 732-427-4497
Fax:
Email: derek.scherer@us.army.mil
2nd TPOC: Len Pohl
Phone: 732-427-3724
Fax:
Email: len.pohl@us.army.mil

OSD06-IA3 TITLE: Situation Awareness and Impact Assessment for Cyber Network Defense

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop technologies enabling situational awareness for large-scale cyber network defense, assessing the impact of adversarial action against a network, and predicting future adversary attack strategy.

DESCRIPTION: Various documents express a specific need for research in the area of cyber situational awareness. These include the requirements of the Global Information Grid (GIG) for enterprise-wide network defense and situational awareness, the “Federal Plan for Cyber Security and Information Assurance Research and Development” by the National Science and Technical Council lists large-scale cyber situational awareness as one of it’s top technical priorities, and the report to the President, “Cyber Security: A Crisis of Prioritization” lists network monitoring and detection as one of ten top priorities for both civilian and military cyber security.

Current methods for alert correlation to detect and identify network attacks rely on data mining approaches that use features or feature sets of network data to discover an attack. This approach has proven useful but has recurrent issues with false positives, limited scalability, limits on detecting highly complex attacks, and adaptability to detecting new types of attacks.

When considering enterprise-wide network defense, current methods are typically insufficient. Recent advances in applying data fusion techniques to cyber network defense are beginning to demonstrate an ability to detect highly complex cyber attacks such as, email phishing, data exfiltration, and long chains of stepping-stone or island-hoping attacks. A high level description of the approaches currently in development was presented as “A Situation Awareness Model Applied to Multiple Domains,” at SPIE 2005, Orlando FL. The approach was further refined to apply to the cyber domain in “Realizing Situation Awareness within a Cyber Environment”, SPIE 2006. The result of this research has advanced the detection of the situation of a network but has yet to fully enable network situation awareness, the assessment of the impact of a cyber attack, or prediction of an attacker’s next step in the execution of an attack.

Given this background, the intent of this SBIR topic is to address these remaining problems of fully enabling network situation awareness, cyber impact assessment, and attacker prediction.

PHASE I: Research methods, techniques, and tools that will automatically assess the situation of a large-scale network, the impact of any cyber attacks, and predict future attacker action within the network. Develop and provide a conceptual design and conceptual prototype of the technology.

PHASE II: Based on Phase I, develop, implement, and validate a prototype system. The prototype should be sufficiently detailed to evaluate scalability, usability, and self-protection from any compromise of its ability to monitor the network’s situation. Define metrics or measures that can be used to evaluate the sufficiency of the prototype’s ability to present the network situation and impact of attacks.

PHASE III DUAL USE APPLICATIONS:
Military application: Enabling an analysts' network situation and impact awareness in critical large-scale networks of military mission systems and contending with malicious network activity and data theft protection.

Commercial application: These technologies directly apply to protecting enterprise networks supporting critical national infrastructures such as electric power, nuclear energy, financial systems, and air traffic control.

REFERENCES:
1. Steinberg, Alan N., Christopher L. Bowman, and Franklin E. White, October 1998. Revisions to the JDL Data Fusion Model, presented at the Joint NATO/IRIS Conference, Quebec.

2. Endsley, Mica R., March 1995. Toward a Theory of Situation Awareness in Dynamic Systems. In Human Factors Journal, Volume 37(1), pages 32-64.

3. Salerno, John J., Michael Hinman, and Douglas Boulware, "A Situation Awareness Model Applied To Multiple Domains", In Proc of the Defense and Security Conference, Orlando, FL, March 2005.

4. Tadda, George, John Salerno, Douglas Boulware, Michael Hinman and Samuel Gorton, "Realizing Situation Awareness within a Cyber Environment", In Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications 2006, edited by Belur V. Dasarathy, Proceedings of SPIE Vol. 6242 (SPIE, Bellingham, WA, 2006) 624204.

5. Valeur, Fredrik, Giovanni Vigna, Christopher Kruegel, and Richard A. Kemmerer, "A Comprehensive Approach to Intrusion Detection Alert Correlation", IEEE Transactions on Dependable and Secure Computing, Vol. 1, No. 3, July-September 2004.

6. "Federal Plan for Cyber Security and Information Assurance Research and Development", A Report by the Interagency Working Group on Cyber Security and Information Assurance, Subcommittee on Infrastructure and Subcommittee on Networking and Information Technology Research and Development, National Science and Technology Council, April 2006.

7. "Cyber Security: A Crisis of Prioritization", Report to the President, Feb 2005, President's Information Technology Advisory Committee.

KEYWORDS: Cyber Situation Assessment, Cyber Situation Awareness, Cyber Impact Assessment, Cyber Attack Anticipation

TPOC: George Tadda
Phone: (315)330-3957
Fax: (315)330-4380
Email: george.tadda@rl.af.mil
2nd TPOC: Dr. John Salerno
Phone: 315-330-3667
Fax:
Email: salernoj@rl.af.mil

OSD06-IA4 TITLE: Multi-Level Voice Over IP (VOIP) Security for Army Environments

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Perform research into Multi-level VoIP security mechanisms for Army networks that are typical of the Army's Future Combat System and Warfighter Information Network- Tactical environments.

DESCRIPTION: Current implementations of VoIP have security issues (regardless of crossing security domains) associated with them including eavesdropping, identify theft, identity fraud, the compromise of call integrity and

denial of service. These technical challenges need to be considered, in addition to the multiple security domain environment. IP networks at various Army sites are now handling an increasing number of voice calls. A Cross Domain Solution (CDS) is needed to enable cross domain phone calls via VoIP with another security domain. The contractor would also incorporate near real-time stripping of keywords or combination of words from among multiple voice IP data packets. This would require word recognition and sentence structure recognition as well as use of statefull inspection and application firewalls (or similar equivalent technologies). A secure communications channel between end users would be required to prevent eavesdroppers. Key exchange between security domains and channel encryption should be explored. To protect against replays and spoofs, the authenticity and "liveness" on both sides needs to be verified. The security solutions formulated would be extremely useful to both the commercial and military worlds. Note that it is anticipated that the security solutions formulated would also be extremely beneficial in the Homeland Defense application by protecting critical cross domain communications and computer network infrastructures.
With the increase of digitization on the battlefield information of many different security classification levels and categories (i.e. unclassified sensitive, US Secret, NATO Secret, Top Secret, etc.) is available. The challenge is to be able to :

- Receive and store data of different classifications
- Keep the data of different classification levels separate; prevent the data of different classifications from mixing
- Allow access of data to users at the lower classification level in a useful form
- Allow sharing of data from lower to higher security classification without allowing access to higher classification data or networks
- Allow users access only to data that their individual clearance allows

Most importantly, do this in a timely and automated fashion AND secure manner. Successful completion of this SBIR would hit upon all these challenges. This work effort would also integrate with future research into high assurance platforms or trusted processor platforms.

PHASE I: Perform a study of possible computer and computer network Multi-level VoIP security mechanisms and a VoIP CDS solution. . A set of alternatives would then be presented to the government. The government would make a joint decision on the most promising techniques to pursue in Phase II.

PHASE II: The most promising techniques emerging from the Phase I effort would be further developed and modeled. A performance description or specification would be developed. A prototype software working model will be delivered.

PHASE III: Military use would include Multi-level VoIP security mechanisms and VoIP CDS solutions for soldiers who are assigned communications equipment in military environments. These devices are becoming more prevalent in the military. Commercial uses would include personnel who are assigned voice communications equipment in such diverse industries as banking, electric power utilities, telephone systems, police and emergency civilian personnel, etc. Applications where sensitive records are kept, such as personnel financial records, or medical records, could also benefit. Note that it is anticipated that the Multi-level VoIP security mechanisms solutions formulated would also be extremely beneficial in the Homeland Defense application by enhancing voice communications between security enclaves..

REFERENCES:
1. http://iase.disa.mil/cds.index.html   Cross Domain Solutions

2. http://voip-info.org/wiki Voice over Internet Protocol Index

3. http://www.fcc.gov/voip Voice over Internet Protocol

KEYWORDS: Cross Domain Solutions, Multi-level security, Voice over Internet Protocol

TPOC: Len Pohl
Phone: 732-427-3724
Fax: 732-427-2062
Email: Len.Pohl@us.army.mil

2nd TPOC: Phil Crichton
Phone: 732-427-2002
Fax:
Email: philip.crichton@us.army.mil

OSD06-IA5 TITLE: Defensive Cyber Craft Systems

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop defensive cybercraft systems that will guarantee the security and assurance of GIG-NCES (Global Information Grid – Net-Centric Enterprise Services) networks and systems.

DESCRIPTION: Security and assurance are critical attributes of the network centric warfare paradigm and are critical to ensuring mission success. One of the problems with the NCES framework is that the networks and systems that comprise the system are complex and dynamic making them difficult to secure. This becomes increasingly important when operations are comprised of joint, allied and coalition forces and when communities of interest are dynamic and distributed. Complex NCES of the future will need to have the capability to provide real-time situational awareness and understanding of network and system activity to commanders to ensure that systems are reliable, secure, available, and correct. A new way of monitoring and managing the NCES is the defensive cyber craft which is an agent that can be launched from a security or network management station. The defensive cybercraft needs to be trusted, positively controlled, cooperative with other cybercraft and also have the capability to accurately map networks, search network nodes, identify and report anomalous and malicious behavior, and take corrective action. This effort will leverage the OSD sponsored Critical Infrastructure Protection and High Confidence, Adaptable Software (CIP/SW) Multi-Disciplinary University Research Initiative (MURI) that included several efforts working on Mobile Code topics that are potentially relevant to the Air Force's new cybercraft initiative.

PHASE I: Describe and develop creative methods, techniques and tools for developing defensive cybercraft systems. The methodologies should in particular address the issue of how to ensure the cyber craft are secure and exhibit safety and liveness properties. The methods should be compatible with major standards and metadata technologies such as XML, so that they can be compatible with the widest range of information assurance products and tools.

PHASE II: Develop, implement and validate a prototype defensive cybercraft system that utilizes the tools and methods from Phase I. The prototypes should be sufficiently detailed to evaluate security, reliability, scalability, usability, and resistance of the cyber craft to adversarial exploitation and malicious attack. Efficiency is also an issue that should be explored, although it is less critical than overall scalability.

PHASE III DUAL USE APPLICATIONS: The increasing focus on network centric warfare means that the ability to secure network operations is paramount. Similarly, in the civilian domain the increased use of electronic commerce is creating a situation where the ability to ensure the security and reliability of networks will become more and more critical over time.

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1. Nelson, David B., “Hard Problems in Information Security,” March 17, 2004. Available online at: http://www.itrd.gov/about/presentations_nco/2004/20040317_irc_dnelson/20040317_irc_dnelson.pdf.

2. IRC Hard Problems List, July 2005. Available from the InfoSec Research Council (IRC) at http://www.infosecresearch.org/contact.html.

3. Criste, Frank, “Implementing the Global Information Grid (GIG) – A Foundation for 2010 Net Centric Warfare (NCW),” May 18, 2004. Available online at: http://www.ndia.org/Content/ContentGroups/Divisions1/International/CRISTE.ppt.

4. Global Information Grid Information Assurance Capability/Technology Roadmap, October 2004. Available to DoD users with PKI certification (CAC) cards at: https://powhatan.iiie.disa.mil/gig/index.html. Some additional public information on GIG information assurance issues can be found: http://iase.disa.mil/.

KEYWORDS: Networks, information assurance, intelligent agents

TPOC: Dr. Kamal Jabbour
Phone: 315-330-1358
Fax:
Email: Kamal.Jabbour@rl.af.mil
2nd TPOC: Joseph Giordano
Phone: 315-330-1518
Fax:
Email: joseph.giordano@rl.af.mil

OSD06-IA6 TITLE: Kernel-mode Software Protection to Prevent Piracy, Reverse Engineering, and Tampering of End-Node Applications

TECHNOLOGY AREAS: Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop advanced kernel-level protection techniques to prevent piracy, reverse engineering, and tampering of high-value software applications.

DESCRIPTION: The Global Information Grid (GIG) requires software security that extends to the end-nodes of the network. Software applications that are vulnerable to malicious alteration, piracy, and reverse engineering can result in the compromise of command, control, and communication channels; as well as piracy and exploitation of central database servers and critical information systems.

The Anti-Tamper-Software Protection Initiative (AT-SPI) Technology Office is charged with preventing piracy, reverse engineering, and malicious alteration of critical national security software and data. Software protection involves developing a defense-in-depth strategy using out-of-band defensive technologies that complement traditional in-band information assurance defenses, such as network firewalls and operating system access controls. AT-SPI defines out-of-band protections as security measures implemented within trusted autonomous processors that are inaccessible to adversaries (e.g., from over-the-wire attacks). Conversely, in-band protections are defined as security measures implemented only in software, and hence are accessible to the adversary (e.g., user-mode software security solutions that contain all the data necessary to launch a direct attack using readily available tools).

It is generally accepted that to defend against certain classes of attacks the protection solution must be at the lowest computer architectural level or highest privilege level possible to avoid being disabled or circumvented [1]. Although not completely inaccessible to a sophisticated adversary, kernel-mode software protections offer the potential to defeat currently available attack tools and thwart many common attack vectors; in particular, over-the-wire attacks, where the attackers do not have physical access to the hardware. A kernel-mode protection product could be coupled to a trusted hardware component to further increase security [2]. In other cases, the kernel-level protection solution could utilize current capabilities that already exist on COTS hardware [3] to increase the overall security of a software-only solution. In addition to providing increased strength to software applications, kernel-mode protections can offer the additional benefit of protecting the operating system from malicious code, such as kernel-level rootkits and spyware.

AT-SPI desires to explore the degree to which software running on commercial-off-the-shelf (COTS) hardware can be made out-of-band to the attackers, by utilizing kernel-level protections. Innovative solutions incorporating ideas from anti-forensics, and direct kernel object manipulation (DKOM) [4] are encouraged, provided they meet the stated requirements listed below and ultimately result in a stable solution.

AT-SPI requires a strategy that balances the need for application security with end-user adoptability and the need to have a minimal impact on performance. As a result, the following requirements of the protection solution must be met without compromising security of the applications being protected: 1) the protection solution must provide minimal run-time performance degradation (e.g. typically ~1-10%, depending on the security requirements of the application), with appropriate security options available for code-owner selection in the security-performance trade-space; 2) administrators must have the ability to monitor high-level resources (e.g., CPU time, disk space, memory) consumed by the protection scheme; 3) administrators must have the ability to completely uninstall the protected application, including any kernel-level components; 4) the protection components, including the uninstaller, must be robust in design and implementation to prevent exploitation and interference with normal operating system functionality, 5) the protection solution installation process must be user-friendly and robust in design. In addition, AT-SPI is interested in kernel-mode protections that target either the Linux or Windows operating system.

PHASE I:
1) Develop a concept for a kernel-level protection solution on Linux or Windows that has capabilities beyond the current state-of-the-art that meets all of the above requirements.
2) Provide design and architecture documents of a prototype tool that demonstrates the feasibility of the concept.

PHASE II:
1) Based on the results from Phase I, refine and extend the design of the protected tool prototype to a fully functioning solution.
2) Provide test and evaluation results demonstrating: 1) robustness of the prototype to both over-the-wire and insider attacks; 2) robustness of the prototype and the uninstaller to exploitation, and 3) ease of maintenance and adoptability of the prototype (as stated in the requirements above).

PHASE III DUAL-USE COMMERCIALIZATION: Robust kernel-level techniques can be used to detect and thwart kernel-level rootkits and spyware, which would benefit both government and commercial enterprises. In addition, this research could be used to improve the security of mobile communication and computing devices, where adding additional hardware to protect software applications or the operating system may not be an option.

REFERENCES:

1. Paul F. Roberts, Anti-spyware Battles Rootkits with Rootkit Tactics, http://www.eweek.com/article2/0,1895,1901907,00.asp, December 14th, 2005.

2. Nick L. Petroni, Jr, et. al, “Copilot - a Coprocessor-based Kernel Runtime Integrity Monitor,” Proc. of the 13th USENIX Symposium, San Diego, CA, Aug. 9-13th, 2004.

3. OS-Independent Runtime Security Services, Intel Corp, http://www.intel.com/technology/comms/download/system_integrity_services.pdf.

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KEYWORDS: Software Protection, Kernel-mode, Loadable Kernel Modules, Direct Kernel Object Manipulation (DKOM), Anti-forensics, Vulnerability Analysis, Software Exploitation, Rootkits

TPOC:	David A. Kapp
Phone:	937 320-9068
Fax:	937 320-9037
Email:	david.kapp@wpafb.af.mil
2nd TPOC:	Christopher Reuter
Phone:	937 320-9068
Fax:	937 320-9037
Email:	christopher.reuter2@wpafb.af.mil

OSD06-IA7 TITLE: Hardware-assisted Software Anti-Tamper

TECHNOLOGY AREAS: Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop advanced hardware-based software protection and tamper monitoring solutions.

DESCRIPTION: Network-centric warfare will require access to critical information systems at the end-nodes of the network. As a result, each end-node must be fortified in order to maintain the integrity of the global network. While numerous commercial-off-the-shelf (COTS) software protection and monitoring products exist today, few are designed to deter nation-state class attacks, and therefore are ineffective against this class of threat. Hardware-based solutions offer the ability to monitor host or network-based software protection products (e.g., anti-virus, anti-spyware, and anti-rootkit applications) that are independent of the operating system of the compute end-nodes. In addition, hardware monitoring systems combined with application-based software protections, offer the promise of flexible and robust security solutions.

The Anti-Tamper-Software Protection Initiative (AT-SPI) Technology Office is charged with preventing piracy, reverse engineering, and malicious alteration of critical national security software and data. Software protection involves developing a defense-in-depth strategy using out-of-band defensive technologies that complement traditional in-band information assurance defenses, such as network firewalls and operating system access controls. AT-SPI defines out-of-band protections as security measures implemented within trusted autonomous processors that are inaccessible to adversaries (e.g., from over-the-wire attacks). Conversely, in-band protections are defined as security measures implemented only in software, and hence are accessible to the adversary (e.g., user-mode software security solutions that contain all the data necessary to launch a direct attack using readily available tools).

Recently, hardware-based tools such as Copilot [1] and Tribble [2] have been developed to aid in digital forensic analysis and malicious code detection. The advantage of these solutions is that they are independent of the operating system, which could become compromised or subverted by kernel-level rootkits or spyware. These products utilize Direct Memory Access (DMA) to monitor, capture, and store the contents of computer memory for integrity verification. The same technology could be used to monitor software protection products running on COTS processors to protect against malicious alteration and/or reverse engineering. In addition, such hardware-based products could also be used to monitor software-based network security products operating at the kernel-level, such as anti-virus, anti-spyware, and firewalls.

AT-SPI seeks to explore and extend innovative software protection anti-tamper techniques using reconfigurable or reprogrammable hardware components. The reconfigurable nature of the solutions will allow security updates in the field, hardware-reuse, and diversity across multiple protected applications. Areas of interest include, but are not limited to: developing hardware-based software tamper detection tools, hardware co-processor solutions, and hardware penalty solutions.

PHASE I:
1) Design and architect a hardware-based software anti-tamper or anti-reverse engineering tool.
2) Provide architectural and design documents of a prototype tool that demonstrates the feasibility of the concept.

PHASE II:
1) Based on the results from Phase I, refine and extend the design of the protection tool prototype to a fully functioning protection solution.
2) Provide an analysis demonstrating the robustness of the product to circumvention or removal of the hardware component (i.e., the solution must be designed to prevent replay attacks).

PHASE III DUAL-USE COMMERCIALIZATION: Tools and technologies for the protection of high-value software against piracy and reverse engineering would be marketable in both the DoD and commercial sectors. Computer security applications that run at the highest privilege level of the computer system, such as anti-virus, anti-spyware, and software firewalls, where software vulnerabilities are a concern, would benefit from kernel-level tamper monitoring technologies. Corporations and government enterprises concerned with digital forensic recovery and integrity verification could also utilize the technology developed under this effort.

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1. Nick L. Petroni, Jr., Timothy Fraser, Jesus Molina, and William A. Arbaugh, "Copilot - a Coprocessor-based Kernel Runtime Integrity Monitor," Proceedings of the 13th USENIX Symposium, San Diego, CA, August 9-13th, 2004, http://www.cs.umd.edu/~waa/pubs/USENIX-copilot.pdf.

2. Brian D. Carter and Joe Grand, "A Hardware-based Memory Acquisition Procedure for Digital Acquisitions," http://www.digital-evidence.org/papers/tribble-preprint.pdf.

KEYWORDS: Software Protection, PCI card, FPGA, Reconfigurable Computing, Software Anti-tamper, Digital Forensics

TPOC: David A. Kapp
Phone: (937) 320-9068
Fax: 937-320-9037
Email: David.Kapp@wpafb.af.mil
2nd TPOC: Christopher Reuter
Phone: (937) 320-9068
Fax: 937-320-9037
Email: Christopher.Reuter2@wpafb.af.mil

OSD06-IA8 TITLE: Software Protection for Embedded Applications

TECHNOLOGY AREAS: Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop software protection for embedded systems to reduce the effectiveness of software reverse engineering attacks.

DESCRIPTION: As warfare becomes increasingly network-centric, the security of software running on embedded systems, including hand-held mobile devices, will be paramount to maintaining the health of the enterprise. Embedded systems can impose additional constraining requirements on software developers, such as small memory and/or storage footprint, real-time operations, hardware limitations, and power consumption restrictions. Embedded applications also have a greater potential for capture and exploitation, given that they are often deployed on weapons systems or carried by military personnel during their mission. In addition, it is becoming necessary to deploy software anti-tamper technologies on critical weapons systems and devices to facilitate foreign military sales (FMS) to our coalition partners.

The Anti-Tamper-Software Protection Initiative (AT-SPI) Technology Office is charged with preventing piracy, reverse engineering, and malicious alteration of critical national security software and data. Software protection involves developing a defense-in-depth strategy using out-of-band defensive technologies that complement traditional in-band information assurance defenses, such as network firewalls and operating system access controls. AT-SPI defines out-of-band protections as security measures implemented within trusted autonomous processors that are inaccessible to adversaries (e.g., from over-the-wire attacks). Conversely, in-band protections are defined as security measures implemented only in software, and hence are accessible to the adversary (e.g., user-mode software security solutions that contain all the data necessary to launch a direct attack using readily available tools).

One area of concern to AT-SPI is the growing number of hardware attack vectors that have been openly published in the literature; including non-invasive, semi-invasive, and invasive attacks [1-4]. Unlike software patches that can be rapidly developed and deployed, hardware upgrades and/or the incorporation of hardware anti-tamper technologies require much longer lead times, are very costly, and, in some cases, impractical.

To address this problem, AT-SPI is interested in exploring innovative software/firmware-based protection techniques that mitigate the effectiveness of these attack vectors, as they apply to systems containing reconfigurable hardware. Areas of interest include, but are not limited to: programmable methods to reduce the effectiveness of data remanence attacks, power analysis attacks, glitch attacks, and bit-stream reverse engineering. Solutions of interest include, but are not limited to: dynamic software/firmware reconfiguration, decoy circuits, improved cryptographic key storage and management architectures, novel circuit design concepts, and methods for circuit design diversity. Although the protections methods of interest are software/firmware-based, they should interface with and be interoperable with hardware mechanisms used to impose penalties on the attackers.

PHASE I:
1) Develop a concept for software protection for an embedded application.
2) Provide architectural and design documents of a prototype tool that demonstrates the feasibility of the concept.

PHASE II:
1) Based on the results from Phase I, refine, extend, and develop the design to a fully functioning protection solution.
2) Provide an attack model and estimate of the effectiveness of the software protection solution.

PHASE III DUAL-USE COMMERCIALIZATION: Tools and technologies for the protection of embedded software applications against exploitation and reverse engineering would be marketable in both the DoD and commercial sectors. The consumer market, where software vulnerabilities in hand-held mobile devices are of increasing concern, would benefit significantly from these technologies.

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2. Sergei Skorobogatov:, “Low temperature data remanence in static RAM, “University of Cambridge, Computer Laboratory, Technical Report UCAM-CL-TR-536, June 2002.

3. Sergei P. Skorobogatov, and Ross J. Anderson, “Optical Fault Induction Attacks,” Cryptographic Hardware and Embedded Systems Workshop (CHES-2002), San Francisco, CA, USA, 13-15 August 2002.

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KEYWORDS: Embedded Systems, Software Protection, Software Exploitation, Hardware Security, Reverse Engineering

TPOC:	Robert Bennington
Phone:	937 320-9068
Fax:	937 320-9037
Email:	robert.bennington@wpafb.af.mil
2nd TPOC:	David A. Kapp
Phone:	937 320-9068
Fax:	937 320-9037
Email:	david.kapp@wpafb.af.mil

OSD06-IA9 TITLE: Software Protection to Deter Malicious Forensic Data Collection and Exploitation

TECHNOLOGY AREAS: Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Prevent malicious forensic data collection, exploitation, and reverse engineering of software protection technologies.

DESCRIPTION: The Global Information Grid (GIG) requires software application security to be deployed on remote computer hosts and mobile communication devices. Application-centric security relies on defense-in-depth to prevent, deter, detect, and react to both over-the-wire and physical hardware attacks. In this model, the software protections must provide robust deterrence to malicious data collection and analysis. In particular, the threat from remote forensic tools used in combination with rootkit-like technology exists and could be used to covertly monitor or analyze software security products or other security related activities on a remote end-node.

The Anti-Tamper-Software Protection Initiative (AT-SPI) Technology Office is charged with preventing piracy, reverse engineering, and malicious alteration of critical national security software and data. Software protection involves developing a defense-in-depth strategy using out-of-band defensive technologies that complement traditional in-band information assurance defenses, such as network firewalls and operating system access controls. AT-SPI defines out-of-band protections as security measures implemented within trusted autonomous processors that are inaccessible to adversaries (e.g., from over-the-wire attacks). Conversely, in-band protections are defined as security measures implemented only in software, and hence are accessible to the adversary (e.g., user-mode software security solutions that contain all the data necessary to launch a direct attack using readily available tools).

Given the sophistication of nation-state adversaries, once must assume that data collection will occur and be used for malicious purposes, such as to understand the protection solution with the intent to bypass the application security mechanisms that reside on the end-nodes of the network. It is not sufficient to simply attempt to prevent such attacks at an outer layer (e.g. using a self-decrypting executable), because such protections leave the inner layer unprotected, once the outer layers are circumvented. To provide a robust solution, one must tightly couple software protections to the end-node compute host’s operating system and hardware, thus forcing the attacker to understand a large amount of information in order to exploit the protection products.

AT-SPI is interested in exploring innovative concepts designed to deter malicious forensic data collection and analysis. Areas of interest include, but are not limited to: distributed user and kernel-space security architectures; software protections that use steganography to hide within the operating system, computer memory, and hard-disks; intra-application covert channels; software decoys, and other anti-forensic protection measures.

PHASE I:
1) Develop a concept for a software protection solution that can prevent or deter malicious forensic data collection and exploitation.
2) Provide architectural and design documents of a prototype tool that demonstrates the feasibility of the concept.

PHASE II:
1) Based on the results from Phase I, refine and extend the design of the protected tool prototype to a fully functioning solution.
2) Provide test and evaluation results demonstrating the robustness of the prototype to both over-the-wire and insider attacks.

PHASE III DUAL-USE COMMERCIALIZATION: Tools and technologies for the protection of high-value software and security products against exploitation and reverse engineering would be marketable in both the DoD and commercial sectors. Commercial vendors and organizations who wish to prevent exfiltration of sensitive data and programs from both malicious insiders and remote attackers would also benefit from this technology.

REFERENCES:

1. Joel McNamara, Secrets of Computer Espionage, John Wiley & Sons, 2003.

2. James Bret Michael, Mikhail Auguston, Neil C. Rowe, and Richard D. Riehle, “Software Decoys: Intrusion Detection and Countermeasures,” Proceedings of the 2002 IEEE Workshop on Information Assurance, United States Military Academy, West Point, NY, June 2002.

3. Covert Channels, Wikipedia, http://en.wikipedia.org/wiki/Covert_channel.

KEYWORDS: Remote Forensics, Software Decoys, Covert Channels, Data Collection, Software Exploitation, Steganography, Data Hiding, Kernel-mode

TPOC:	David A. Kapp
Phone:	937 320-9068
Fax:	937 320-9037
Email:	david.kapp@wpafb.af.mil
2nd TPOC:	Christopher Reuter
Phone:	937 320-9068
Fax:	937 320-9037
Email:	christopher.reuter2@wpafb.af.mil

OSD06-I10 TITLE: <u>Software Protection through Specialized Commodity Processors</u>

TECHNOLOGY AREAS: Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop software protections that are based on commonly available specialized processing systems.

DESCRIPTION: Initiatives such as the Trusted Computing Group involve using trusted processor modules to protect and authenticate application software. Currently, a major weakness of most COTS software protections is that they are entirely software-based, and all components of the protection are built into the protected application. Attackers can analyze the protections as the application runs and systematically remove them from the protected software. One way to inhibit attackers is therefore to move aspects of protection to hardware systems that are difficult to observe or analyze.

The Anti-Tamper-Software Protection Initiative (AT-SPI) Technology Office is charged with preventing piracy, reverse engineering, and malicious alteration of critical national security software and data. Software protection involves developing a defense-in-depth strategy using out-of-band defensive technologies that complement traditional in-band information assurance defenses, such as network firewalls and operating system access controls. AT-SPI defines out-of-band protections as security measures implemented within trusted autonomous processors that are inaccessible to adversaries (e.g., from over-the-wire attacks). Conversely, in-band protections are defined as security measures implemented only in software, and hence are accessible to the adversary (e.g., user-mode software security solutions that contain all the data necessary to launch a direct attack using readily available tools).

Modern COTS computer systems have access to a number of processors in addition to the central processing unit (CPU). A system may contain powerful graphics, sound, and network processors, and it may have access to external processing systems such as audio players and handheld PCs. A growing number of systems also contain trusted processor modules (TPMs), which contain both a CPU and a minimal amount of memory [1]. Some of these, notably graphics processors, are already being used for non-standard computation [2]. These non-CPU resources could be applied to software security in a variety of ways. For instance, most advanced software reverse engineering tools are currently focused on the Intel IA-32 instruction set. However, supplementary processors typically use instruction sets that are significantly different than IA-32, making analysis of code for these processors more difficult. External processing systems with their own local storage can potentially go one step further by hiding the code entirely from an attacker, making access to the code more difficult. Another possibility is that an application could make use of different processors within a system to tie itself to that particular system or a similar class of systems.

AT-SPI seeks to explore and extend innovative software protection techniques that use standard commodity processors to defend against reverse engineering, tampering, and/or piracy. Areas of interest include, but are not limited to: developing secure execution frameworks, tamper detection techniques, and advanced node-locking techniques.

PHASE I:
1) Design and architect a software protection tool that is based around a commodity processor (not a PC CPU).
2) Provide architectural and design documents of a prototype tool that demonstrates the feasibility of the concept.

PHASE II:
1) Based on the results from Phase I, refine and extend the design of the protection tool prototype to a fully functioning protection solution.
2) Provide an analysis demonstrating the robustness of the product to circumvention or removal of the hardware component (i.e., the solution must be designed to prevent replay attacks).

PHASE III DUAL-USE COMMERCIALIZATION: Tools and technologies for the protection of high-value software against reverse engineering, tampering, and piracy would be marketable in both the DOD and commercial sectors. Computer security applications, where software vulnerabilities are a concern, would benefit from these technologies.

REFERENCES:
1. “Trusted Computing Group: TPM.” https://www.trustedcomputinggroup.org/groups/tpm/.

2. “General-Purpose Computation Using Graphics Hardware.” http://www.gpgpu.org.

KEYWORDS: Software Protection, Software Anti-tamper, Software Reverse Engineering

TPOC: Jason Cheatham
Phone: 937 320-9068
Fax: 937 320-9037
Email: jason.cheatham@wpafb.af.mil
2nd TPOC: David A. Kapp
Phone: 937 320-9068
Fax: 937 320-9037
Email: david.kapp@wpafb.af.mil

OSD06-I11 TITLE: <u>Software Situational Awareness for End-node Authentication</u>

TECHNOLOGY AREAS: Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop self-aware software protections that use hardware, software, and environmental characteristics to identify whether the software application is running in a hostile environment, such as a reverse engineering laboratory.

DESCRIPTION: Network-centric security requires authentication at the end-nodes of a network where compromises most often occur. Software executing on network end-nodes requires a situational or self-awareness to be able to identify when a tamper event has occurred, and whether the software is running on the intended computer system or in a hostile reverse engineering laboratory environment.

The Anti-Tamper-Software Protection Initiative (AT-SPI) Technology Office is charged with preventing piracy, reverse engineering, and malicious alteration of critical national security software and data. Software protection involves developing a defense-in-depth strategy using out-of-band defensive technologies that complement traditional in-band information assurance defenses, such as network firewalls and operating system access controls. AT-SPI defines out-of-band protections as security measures implemented within trusted autonomous processors that are inaccessible to adversaries (e.g., from over-the-wire attacks). Conversely, in-band protections are defined as security measures implemented only in software, and hence are accessible to the adversary (e.g., user-mode software security solutions that contain all the data necessary to launch a direct attack using readily available tools).

AT-SPI is currently performing research in idiosyncratic signatures in order to identify unique characteristics that would enable an application to be bound to a specific piece of hardware. Efforts in this area employ additional hardware components to measure these signatures or rely on defects in COTS components as a discriminator.

AT-SPI desires to explore research in self-aware protection technologies that would allow protected software to bind to a dynamic runtime environment without the need for additional hardware or hardware modifications. The primary objectives of this research are to: 1) explore dependable and readily available software-assessable machine heuristics such as, Advanced Configuration and Power Interface (ACPI) environmental properties, usage characteristics, and hardware/software discriminates; and 2) develop a protection solution that utilizes these properties to react or impose penalties on attackers attempting to pirate or execute the software in a hostile environment.

PHASE I:
1) Develop a concept for self-aware software protection technology that can determine whether the software is running on the intended computer system or in a reverse engineering laboratory environment.
2) Provide architectural and design documents of a prototype tool that demonstrates the feasibility of the concept.

PHASE II:
1) Based on the results from Phase I, refine and extend the design of the protection tool prototype to a fully functioning protection solution.
2) Provide test and evaluation results demonstrating the robustness of the tool to circumvention and/or exploitation.

PHASE III DUAL-USE COMMERCIALIZATION: Tools and technologies for the protection of high-value software against piracy and reverse engineering would be marketable in both the DoD and commercial sectors. Commercial organizations where Digital Rights Management (DRM) is a concern would benefit from this technology.

REFERENCES:
1. A. Main and P.C. van Oorschot, “Software Protection and Application Security: Understanding the Battleground,” State of the Art and Evolution of Computer Security and Industrial Cryptography, June 2003, Belgium, Springer-Verlag LNCS, http://www.scs.carleton.ca/~paulv/papers/softprot8a.pdf.

2. Peter Andras and Bruce G. Charlton, “Self-Aware Software – Will It Become a Reality?” SELF-START 2004, LNCS 3460, pp. 229-259, 2005, Springer-Verlag, Berlin Heidelberg, 2005, http://www.staff.ncl.ac.uk/peter.andras/PABCsasw.pdf.

3. ACPI Specification, http://www.acpi.info.

KEYWORDS: ACPI, Machine Heuristics, Software-Hardware Binding, Usage Characteristics, Reverse Engineering, Software Exploitation

TPOC: David A. Kapp
Phone: 937 320-9068
Fax: 937 320-9037
Email: David.Kapp@wpafb.af.mil
2nd TPOC: Christopher Reuter
Phone: 937 320-9068
Fax: 937 320-9037
Email: christopher.reuter2@wpafb.af.mil

OSD06-I12 TITLE: Light-weight Virtualization as a Defense against Reverse Engineering

TECHNOLOGY AREAS: Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop tools and techniques that utilize light-weight virtualization as a defense against reverse engineering.

DESCRIPTION: The Global Information Grid (GiG) requires security that extends to the end-nodes of the network. Application-centric security relies on defense-in-depth to prevent and deter both over-the-wire and local attacks against executables stored or running on varied end-nodes such as desktop hosts, mobile communication devices, and high performance computers. In this model, the software protections must provide robust deterrence against adversaries using hardware and software based analysis tools used to extract key Intellectual Property from within an application. Intellectual Property consists of both algorithms, such as weapon design software; as well as DoD derived fixed and floating point data for modeling and simulation of advanced weapon systems.

The Anti-Tamper-Software Protection Initiative (AT-SPI) Technology Office is charged with preventing piracy, reverse engineering, and malicious alteration of critical national security software and data. An area of high interest to AT-SPI is the capabilities of nation-state adversaries. Given the sophistication of theses adversaries, one must assume that the reverse engineering of high-value applications will occur to extract key Intellectual Property. It is not sufficient to simply attempt to prevent such attacks with a single outer layer (e.g., such as encryption or anti-debugging). Such protections are brittle due to a single point of failure. Attacks against these layers are often automated causing significant reduction in time and effort to attack for subsequent defeats. To provide a robust solution, one must force the attacker to understand a large amount of information that is unique between each instance of the protection.

Virtualization has the potential to provide a robust protection technique by using unique byte code instruction sets to obfuscate key Intellectual Property. Existing virtualization methods that have been evaluated for their protection strength have often imposed unacceptable performance constraints, been susceptible to black-box analysis attacks, or attacks using software and hardware emulators.

AT-SPI is interested in sponsoring research into innovative tools and techniques to apply virtualization technologies that withstand subsequent attacks by highly skilled and dedicated adversaries while continuing to meet execution performance requirements. Several sub-areas of interest include:
- Technology to interweave multiple, unique, light-weight virtualization systems and instruction sets that reinforce each other within a protected binary executable.
- Technology to reduce the threat of black-box attacks against the virtualized key Intellectual Property.

- Technology that improves the efficiency of the virtualization by maximizing the protection of key Intellectual Property while maintaining application performance requirements through either improvements to the virtualization technology or through intelligent targeting and application of existing technologies.
- Innovative technology to utilize virtualization to protect key Intellectual Property in the application such as algorithms and data values (both fixed and floating point).

PHASE I:
1) Develop a concept for a set of tools or techniques that addresses at least one of the sub-goals listed above. Techniques should be applicable across operating systems and hardware architectures.
2) Demonstrate the innovative nature of this approach as well as an understanding of challenges related to addressing additional sub-goals in Phase II.
3) Demonstrate the effectiveness of the concept through the design and development of a deliverable prototype tool that proves the feasibility of the concept through tests of the performance impact as well as the effectiveness of the protection.

PHASE II:
1) Based on the results from Phase I, refine and extend the design of the tool prototype to a complete toolset that addresses additional sub-goals.
2) Develop an enhanced prototype toolset using industry best practices.
3) Perform a detailed assessment of the toolset on a variety of real-world relevant test applications.
a. Perform security penetration attacks to analyze the protection provided and deliver detailed results of attacks and protection effectiveness, to include attack trees, processes, times and similar data
b. Perform detailed performance impact evaluations.

PHASE III DUAL-USE COMMERCIALIZATION: Development of tools and technologies for the protection of high-value software against reverse engineering would be marketable in both the DoD and commercial sectors. Computer applications where software vulnerabilities are a concern would additionally benefit from these technologies.

REFERENCES:
1. Susante Nanda and Tzi-cker Cjiueh, “A Survey on Virtualization technologies,” http://www.ecsl.cs.sunysb.edu/tr/TR179.pdf.

2. The DynamoRIO Collection, http://www.cag.lcs.mit.edu/dynamorio/.

3. Jim Smith and Ravi Nair, “Virtual Machines: Versatile Platforms for Systems and Processes,” Morgan Kaufmann, 2005.

4. Lt. Col Arthur F. Huber II, USAF and Jennifer M. Scott, “The Role and Nature of AntiTamper Techniques in U.S. Defense Acquisition,” 1999.

KEYWORDS: Binary Diversity, Algorithm Analysis, Virtualization, Application Centric Security

TPOC: Capt David Chaboya
Phone: (937) 320-9068
Fax: 937-320-9037
Email: David.Chaboya@wpafb.af.mil
2nd TPOC: Jason Cheatham
Phone: (937) 320-9068
Fax: 937-320-9037
Email: Jason.Cheatham@wpafb.af.mil

OSD06-I13 TITLE: Advanced Software Exploitation Prevention

TECHNOLOGY AREAS: Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop new approaches and tools to mitigate software exploitation.

DESCRIPTION: Network-centric warfare requires deployment of software application security to maintain the integrity of the information systems at the edges of the network where compromises are most likely to occur. In the arms-race between cyber attackers and software protection practitioners, continuous research is required to maintain a high-level of strength in software protection products. A recent example is SubVirt, a virtual machine rootkit, co-developed by Microsoft Research and the University of Michigan [1]. Detecting malware of this complexity and sophistication will be of paramount importance as critical resources are made available on the Global Information Grid (GiG).

The Anti-Tamper-Software Protection Initiative (AT-SPI) Technology Office is charged with preventing piracy, reverse engineering, and malicious alteration of critical national security software and data. Based upon previous research findings, AT-SPI is interested in the following areas related to advanced exploitation mitigation:

1) Replay attack prevention by improving software-hardware binding. Combining software with trusted hardware results in a protection solution that is only as good as the weakest link. In this scenario, the interface between software and hardware is often the focus of attack. AT-SPI seeks to improve software/trusted hardware binding techniques that would prevent replay attacks (i.e., running the software without the trusted hardware component).

2) Anti-disassembly as a defense against reverse engineering. Static analysis is often used to analyze protected software executables. Using this form of analysis, the adversary hopes to study the protection process without running the binary, which could invoke a software or hardware penalty. In the cases where the software executable is fully encrypted or packed, the adversary may run the executable until the point at which the executable is decrypted and then dump the memory contents to a file for further static analysis. AT-SPI seeks to develop improved methods to prevent static analysis, including, but not limited to improved anti-disassembly.

3) Hiding cryptographic algorithms and keys in binary executables. Software running on COTS hardware eventually executes “in the clear” or unencrypted. While protection solutions exist that allow out-of-band key management strategies, not all of these solution are practical in every use-case scenario. Hence, AT-SPI seeks innovative strategies to hide cryptographic algorithms and keys that may be used either within the executable or injected into the executable at runtime from a trusted processor.

4) Improving protections used in combination. There are several known cases where the strength of software-only protections can be multiplied when used in combination. For example, check-summing used in conjunction with anti-debugging can produce protections whose strength is greater than when the same protections are applied independently of one another. AT-SPI seeks to explore innovative techniques that combine protection methods to improve the overall strength of protection products.

5) Develop anti-emulation/anti-virtualization defenses. A major threat to software protection technology is emulation or virtualization that can be used to bypass different forms of protection technologies (e.g., anti-debugging, check-summing). AT-SPI seeks to explore techniques beyond what is currently known in the literature that can be used to detect when the application is being run in an emulator or virtual machine environment.

PHASE I:
1) Develop a concept for an advanced protection tool that has capabilities beyond the current state-of-the-art.
2) Provide architectural and design documents of a prototype tool that demonstrates the feasibility of the concept.

PHASE II:

1) Based on the results from Phase I, refine and extend the design of the protection tool prototype to a fully functioning protection solution.
2) Provide test and evaluation results demonstrating the robustness of the tool to circumvention and/or exploitation.

PHASE III DUAL-USE COMMERCIALIZATION: Tools and technologies for the protection of high-value software against piracy and reverse engineering would be marketable in both the DoD and commercial sectors. Computer applications where software vulnerabilities are a concern would benefit from these technologies.

REFERENCES:
1. Samuel T. King, Peter M. Chen, Yi-Min Wang, Chad Verbowski, Helen J. Wang, and Jacob R. Lorch, "SubVirt; Implementing Malware with Virtual Machines," http://www.eecs.umich.edu/virtual/papers/king06.pdf.

2. J. Giffin, M. Christodorescu, and L. Kruger "Strengthening Software Self-Checksumming via Self-Modifying Code," 21st Annual Computer Security Applications Conference, Tucson, AZ, December 5-8, 2005, pp. 18-27.

3. Cullen Linn, Saumya Debray, and John Kececioglu, "Enhancing Software Tamper-Resistance via Stealthy Address Computations," 19th Annual Computer Security Applications Conference (ACSAC), Las Vegas, Nevada, 2003.

4. John Scott Robin and Cynthia E. Irvine, "Analysis of the Intel Pentium's Ability to Support a Secure Virtual Machine Monitor," http://www.cs.nps.navy.mil/people/faculty/irvine/publications/2000/VMM-usenix00-0611.pdf.

KEYWORDS: Replay Attacks, Emulation, Virtualization, Anti-disassembly, Reverse Engineering, Software Exploitation

TPOC:	David A. Kapp
Phone:	(937) 320-9068
Fax:	937-320-9037
Email:	david.kapp@wpafb.af.mil
2nd TPOC:	Robert Bennington
Phone:	(937) 320-9068
Fax:	937-320-9037
Email:	robert.bennington@wpafb.af.mil

OSD06-PR1 TITLE: Solid Propellant Binders for Solid Rocket Motors

TECHNOLOGY AREAS: Space Platforms, Weapons

OBJECTIVE: Develop of higher energy density solid propellant binder that possess acceptable physical properties for higher performing solid propellants to advance space access, and ballistic missile applications.

DESCRIPTION: The DoD requires higher performing solid binder for use on space access launch vehicles, strategic, tactical and missile defense systems. Current propellant binders are unable to provide the performance needed to meet the performance goals of the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Phase III goals (Isp +8% and Improve Mass Fraction +35%). These propellants must possess higher energy and energy density while maintaining acceptable hazard, mechanical, and processing properties. The research areas may include but are not limited to the following: identification, synthesis, and characterization of new binders to increase the energy density of formulated solid propellant mixtures while meeting other required attributes (e.g. hazard classification, lifetime, cost (in full scale production), performance); development of improved (e.g. scale, yield, cost, synthesis pathway modeling) energetic ingredient synthesis methods. This capability will support current and future DoD ballistic, tactical missiles, missile defense systems and space launch applications. The proposed technology development efforts are anticipated to build upon, and provide significant enhancement over, existing domestic and foreign capability. To increase the probability of successful transition to Phase III, the technology development efforts proposed should leverage existing capability and ongoing SRM technology development efforts to the maximum extent possible.

PHASE I: Conceive and identify potential candidate binders, sensitivity models, and/or synthesis methods and screen them based on their theoretical performance and other parameters. Design research strategies to synthesize and characterize the key properties of promising new binders. Prepare sufficient new binder quantities in laboratory scale to allow determination of structure and permit necessary ingredient stability and sensitivity tests to be conducted.

PHASE II: Develop and refine scale-up synthesis procedure for new characterized compounds to be evaluated in formulated propellant development. Evaluate candidate propellant formulations containing the new characterized binders in aging, compatibility, mechanical property, thermal stability, sensitivity and performance characteristics for solid propellant applications.

PHASE III DUAL USE COMMERCIALIZATION: Further scale-up and characterize physical properties of new binders and/or formulated propellants tailored for commercial, civil and military space launch and other military applications. Demonstrate high energy density propellant in sub-scale motor test.

REFERENCES:
1. Advanced Energetic Materials, National Research Council of the National Academies assessment, ed. R. L. Atkins, The National Academies Press, Washington, DC, 2004, pp.5-15.

2. “Request for S&T Representatives for Directed Energy Weapon, Energetic Materials, and Cruise Missile/Cruise Missile Defense Assessments,” Memorandum for Assistant Secretary of the Army (Acquisition), Logistics and Technology), Assistant Secretary of the Navy (Research, Development and Acquisition), Assistant Secretary of the Air Force (Acquisition), signed by Stephen. A. Cambone (Under Secretary of Defense for Intelligence) and Ronald. M. Sega (Director, Defense Research and Engineering), Jan. 28, 2004.

KEYWORDS: Space Access, Strategic and Tactical Missiles, High Energy Density Ingredients, HEDM, Solid Propellants, Energetic Materials, Energetic Ingredients, Energetic Binders, Binder, Specific Impulse, Density Impulse, Insensitive, Density, Heat of Formation, Impact Sensitivity, Shock Sensitivity, Friction Sensitivity, Thermal Stability, Chemical Compatibility, IHPRPT

TPOC: Dr. Tom Hawkins
Phone: 661-275-5449
Fax:
Email: Tommy.Hawkins@edwards.af.mil

OSD06-PR2 TITLE: Solid Propellant Burn rate modifiers for Solid Rocket Motors

TECHNOLOGY AREAS: Space Platforms, Weapons

OBJECTIVE: Develop of higher energy density solid propellant burn rate modifiers that possess acceptable physical properties for higher performing solid propellants to advance space access, and ballistic missile applications.

DESCRIPTION: The DoD requires higher performing solid burn rate modifiers for use on space access launch vehicles, strategic, tactical and missile defense systems. Current energetic burn rate modifiers are unable to provide the performance needed to meet the performance goals of the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Phase III goals (Isp +8% and Improve Mass Fraction +35%).. These propellants must possess higher energy density while maintaining acceptable hazard, mechanical, and processing properties. The research areas may include but are not limited to the following: identification, synthesis, and characterization of new burn rate modifierss to increase the energy density of formulated solid propellant mixtures while meeting other required attributes (e.g. hazard classification, lifetime, cost (in full scale production), performance); development of improved (e.g. scale, yield, cost, synthesis pathway modeling) energetic ingredient synthesis methods. This capability will support current and future DoD ballistic, tactical missiles, missile defense systems and space launch applications. The proposed technology development efforts are anticipated to build upon, and provide significant enhancement over, existing domestic and foreign capability. To increase the probability of successful transition to Phase III, the technology development efforts proposed should leverage existing capability and ongoing SRM technology development efforts to the maximum extent possible.

PHASE I: Conceive and identify potential candidate burn rate modifiers, sensitivity models, and/or synthesis methods and screen them based on their theoretical performance and other parameters. Design research strategies to synthesize and characterize the key properties of promising new burn rate modifiers. Prepare sufficient new burn rate modifier quantities in laboratory scale to allow determination of structure and permit necessary ingredient stability and sensitivity tests to be conducted.

PHASE II: Develop and refine scale-up synthesis procedure for new characterized compounds to be evaluated in formulated propellant development. Evaluate candidate propellant formulations containing the new characterized burn rate modifiers in aging, compatibility, mechanical property, thermal stability, sensitivity and performance characteristics for solid propellant applications.

PHASE III DUAL USE COMMERCIALIZATION: Further scale-up and characterize physical properties of new burn rate modifiers and/or formulated propellants tailored for commercial, civil and military space launch and other military applications. Demonstrate high energy density propellant in sub-scale motor test.

REFERENCES:
1. Advanced Energetic Materials, National Research Council of the National Academies assessment, ed. R. L. Atkins, The National Academies Press, Washington, DC, 2004, pp.5-15.

2. “Request for S&T Representatives for Directed Energy Weapon, Energetic Materials, and Cruise Missile/Cruise Missile Defense Assessments,” Memorandum for Assistant Secretary of the Army (Acquisition), Logistics and Technology), Assistant Secretary of the Navy (Research, Development and Acquisition), Assistant Secretary of the Air Force (Acquisition), signed by Stephen. A. Cambone (Under Secretary of Defense for Intelligence) and Ronald. M. Sega (Director, Defense Research and Engineering), Jan. 28, 2004.

KEYWORDS: Space Access, Strategic and Tactical Missiles, High Energy Density Ingredients, HEDM, Solid Propellants, Energetic Materials, Energetic Ingredients, Energetic Binders and Plasticizers, Burn rate modifier, Oxidizer, Burn Rate Modifier, Specific Impulse, Density Impulse, Insensitive, Density, Heat of Formation, Impact Sensitivity, Shock Sensitivity, Friction Sensitivity, Thermal Stability, Chemical Compatibility, IHPRPT.

TPOC: Dr. Tom Hawkins
Phone: 661-275-5449
Fax:
Email: Tommy.Hawkins@edwards.af.mil

OSD06-PR3 TITLE: <u>Solid Propellant Fuels for Solid Rocket Motors</u>

TECHNOLOGY AREAS: Space Platforms, Weapons

OBJECTIVE: Develop of higher energy density solid propellant fuel that possess acceptable physical properties for higher performing solid propellants to advance space access, and ballistic missile applications.

DESCRIPTION: The DoD requires higher performing solid fuels for use on space access launch vehicles, strategic, tactical and missile defense systems. Current energetic fuels are unable to provide the performance needed to meet the performance goals of the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Phase III goals (Isp +8% and Improve Mass Fraction +35%). These propellants must possess higher energy density while maintaining acceptable hazard, mechanical, and processing properties. The research areas may include but are not limited to the following: identification, synthesis, and characterization of new fuelss to increase the energy and energy density of formulated solid propellant mixtures while meeting other required attributes (e.g. hazard classification, lifetime, cost (in full scale production), performance); development of improved (e.g. scale, yield, cost, synthesis pathway modeling) energetic ingredient synthesis methods. This capability will support current and future DoD ballistic, tactical missiles,   missile defense systems and space launch applications. The proposed technology development efforts are anticipated to build upon, and provide significant enhancement over, existing domestic and foreign capability. To increase the probability of successful transition to Phase III, the technology development efforts proposed should leverage existing capability and ongoing SRM technology development efforts to the maximum extent possible.

PHASE I: Conceive and identify potential candidate fuels, sensitivity models, and/or synthesis methods and screen them based on their theoretical performance and other parameters. Design research strategies to synthesize and characterize the key properties of promising new fuels. Prepare sufficient new fuel quantities in laboratory scale to allow determination of structure and permit necessary ingredient stability and sensitivity tests to be conducted.

PHASE II: Develop and refine scale-up synthesis procedure for new characterized compounds to be evaluated in formulated propellant development. Evaluate candidate propellant formulations containing the new characterized fuels in aging, compatibility, mechanical property, thermal stability, sensitivity and performance characteristics for solid propellant applications.

PHASE III DUAL USE COMMERCIALIZATION: Further scale-up and characterize physical properties of new fuels and/or formulated propellants tailored for commercial, civil and military space launch and other military applications. Demonstrate high energy density propellant in sub-scale motor test.

REFERENCES:
1. Advanced Energetic Materials, National Research Council of the National Academies assessment, ed. R. L. Atkins, The National Academies Press, Washington, DC, 2004, pp.5-15.

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KEYWORDS: Space Access, Strategic and Tactical Missiles, High Energy Density Ingredients, HEDM, Solid Propellants, Energetic Materials, Energetic Ingredients, Energetic Binders and Plasticizers, Fuel, Oxidizer, Burn Rate Modifier, Specific Impulse, Density Impulse, Insensitive, Density, Heat of Formation, Impact Sensitivity, Shock Sensitivity, Friction Sensitivity, Thermal Stability, Chemical Compatibility, IHPRPT.

TPOC: Dr. Tom Hawkins
Phone: 661-275-5449
Fax:
Email: Tommy.Hawkins@edwards.af.mil

OSD06-PR4 TITLE: Solid Propellant Oxidizers for Solid Rocket Motors

TECHNOLOGY AREAS: Space Platforms, Weapons

OBJECTIVE: Develop of higher energy density solid propellant oxidizer that possess acceptable physical properties for higher performing solid propellants to advance space access, and ballistic missile applications.

DESCRIPTION: The DoD requires higher performing solid oxidizers for use on space access launch vehicles, strategic, tactical and missile defense systems. Current energetic oxidizers are unable to provide the performance needed to meet the performance goals of the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Phase III goals (Isp +8% and Improve Mass Fraction +35%).. These propellants must possess higher energy and energy density while maintaining acceptable hazard, mechanical, and processing properties. The research areas may include but are not limited to the following: identification, synthesis, and characterization of new oxidizerss to increase the energy density of formulated solid propellant mixtures while meeting other required attributes (e.g.

hazard classification, lifetime, cost (in full scale production), performance); development of improved (e.g. scale, yield, cost, synthesis pathway modeling) energetic ingredient synthesis methods. This capability will support current and future DoD ballistic, tactical missiles, missile defense systems and space launch applications. The proposed technology development efforts are anticipated to build upon, and provide significant enhancement over, existing domestic and foreign capability. To increase the probability of successful transition to Phase III, the technology development efforts proposed should leverage existing capability and ongoing SRM technology development efforts to the maximum extent possible.

PHASE I: Conceive and identify potential candidate oxidizers, sensitivity models, and/or synthesis methods and screen them based on their theoretical performance and other parameters. Design research strategies to synthesize and characterize the key properties of promising new oxidizers. Prepare sufficient new oxidizer quantities in laboratory scale to allow determination of structure and permit necessary ingredient stability and sensitivity tests to be conducted.

PHASE II: Develop and refine scale-up synthesis procedure for new characterized compounds to be evaluated in formulated propellant development. Evaluate candidate propellant formulations containing the new characterized oxidizers in aging, compatibility, mechanical property, thermal stability, sensitivity and performance characteristics for solid propellant applications.

PHASE III DUAL USE COMMERCIALIZATION: Further scale-up and characterize physical properties of new oxidizers and/or formulated propellants tailored for commercial, civil and military space launch and other military applications. Demonstrate high energy density propellant in sub-scale motor test.

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2. "Request for S&T Representatives for Directed Energy Weapon, Energetic Materials, and Cruise Missile/Cruise Missile Defense Assessments," Memorandum for Assistant Secretary of the Army (Acquisition), Logistics and Technology), Assistant Secretary of the Navy (Research, Development and Acquisition), Assistant Secretary of the Air Force (Acquisition), signed by Stephen. A. Cambone (Under Secretary of Defense for Intelligence) and Ronald. M. Sega (Director, Defense Research and Engineering), Jan. 28, 2004.

KEYWORDS: Space Access, Strategic and Tactical Missiles, High Energy Density Ingredients, HEDM, Solid Propellants, Energetic Materials, Energetic Ingredients, Oxidizer, Specific Impulse, Density Impulse, Insensitive, Density, Heat of Formation, Impact Sensitivity, Shock Sensitivity, Friction Sensitivity, Thermal Stability, Chemical Compatibility, IHPRPT.

TPOC: Dr. Tom Hawkins
Phone: 661-275-5449
Fax:
Email: Tommy.Hawkins@edwards.af.mil

OSD06-PR5 TITLE: <u>Theoretical Estimation Of New Propellant Ingredient Heats Of Condensation</u>

TECHNOLOGY AREAS: Space Platforms, Weapons

OBJECTIVE: Develop and validate physics based models for estimating heats of condensation, needed to relate ab initio gas phase calculations to solid phase heats of formation.

DESCRIPTION: The synthesis of new energetic rocket ingredients is guided by well developed generalized theoretical tools for estimating specific impulse. These computations require inputs for the formulas and heats of formation for proposed new ingredients. Of these, the formula is straightforward, being either known or projected as a potentially useful synthesis target. Heats of formation are more problematic. Scale-up must be relatively advanced, to the level of tens of grams, before a reliable calorimetric heat of formation can be measured. Prior to that, only theoretical estimates are available. Empirical methods can yield useful estimates if analogous model compounds are known. Quantum mechanical (QM) approaches offer more generality, except that they are limited to gaseous molecules, leaving a gap to be bridged—the heat of condensation (HC). Current methods for HC estimation introduce uncertainties similar to that of the QM estimate of the gas, partially undercutting the large computational investment for the QM estimate. Reliance upon HC correlations involving model compounds runs into a data base limit for larger molecules, which risk dissociation before reaching the higher temperatures at which their vaporization would need to be measured.

PHASE I: The effort should include: literature review of heat of condensation estimation methods, establishment of current capabilities and limitations, and preliminary exploration of potential advances in the physical models.

PHASE II: The effort should include: continued literature review; development of a physical and mathematical model for estimating heats of condensation, preferably with reduced reliance upon model compounds; implementation as a computer program. Deliverables should include: literature review results; final software, diagnostics and associated documentation.

PHASE III: DUAL USE COMMERCIALIZATION: Commercial and civil launch vehicles, gas-generators, and explosive are proposed for several military applications, and they would also be expected to have many commercial customers.

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KEYWORDS: Propellant ingredients, heat of condensation, heat of vaporization, heat of sublimation, heat of formation, estimation, correlation, quantum mechanics

TPOC: Dr. Tom Hawkins
Phone: 661-275-5449
Fax:
Email: Tommy.Hawkins@edwards.af.mil

OSD06-UM1 TITLE: Littoral Navigation Autonomy for Unmanned Surface Vehicle

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

OBJECTIVE: To provide research in autonomous algorithms and sensors for safe navigation and obstacle avoidance of unmanned surface vehicles in littoral and riverine environments.

DESCRIPTION: Unmanned systems are increasingly being used to provide persistent littoral surveillance for a broad range of missions. As missions increase in complexity, multiple unmanned vehicles of different classes will need the ability to operate autonomously in the littorals. Current unmanned surface vehicles are remotely operated when in the vicinity of other vessels. This uses valuable manpower that could be applied to higher-level functions enabling efficient command and control of multiple vehicles. Unmanned Undersea Vehicles stay submerged to avoid the surface threats. As USVs and UUV's increase in the roles to patrol area, harbor and river security, and homeland defense; the higher the need for automated operations of unmanned vehicles in the littorals.

Development of new control algorithms is needed to enable autonomous navigation of a USV or UUV in the littoral environments. These algorithms then may also be applied to unmanned ground vehicles as well for urban operations. These control algorithms will accept inputs from radar, electro optic cameras, infrared cameras and other new sensors to detect objects in the unmanned vehicle's path. The algorithms will then use the US Coats Guard "NAV rules" (reference 1) to safely navigate around other vessels and obstacles. This will enable safe operation of USVs and UUVs in the littorals and significantly reduce the probability of collision with a personal or commercial vessel.

PHASE I: Phase I will consist of research into types sensors for detection and tracking of objects, commercial, and personal vessels on the water. Trade study should be conducted to perform analysis on key performance features of each sensor. Research should also be conducted on control algorithms that can enable a USV or UUV to follow the US Coast Guard "NAV Rules" and avoid personal and commercial traffic in the area.

PHASE II: Phase II would consist of developing prototypes of the system to include the sensors and the autonomous control algorithms. The prototype will then be tested on a manned rigid hull inflatable boat by a display screen to show the RHIB drive the path to follow to avoid the vessels or obstacles.

PHASE III DUAL USE COMMERCIALIZATION: Integration on a USV for a demonstration in a busy harbor or riverine environment. This will include testing in various conditions to include rain, fog, and high sea states.

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TPOC: Daniel Deitz
Phone: 202-781-2670
Fax:
Email: daniel.deitz@navy.mil

OSD06-UM2 TITLE: Cooperative Tracking of Elusive Dismounts by Human Assisted UAV-UGV

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Weapons

OBJECTIVE: Develop tightly coupled on-board sensing, tracking and control algorithms that allow a small UAV and a small UGV to cooperatively get and keep "cross hairs on target" even as the target, typically a dismount, attempts to evade detection in complex urban settings. The focus is on the advanced on-board algorithm technologies that allow for operation by a single operator.

DESCRIPTION: The development of human robotic interaction technology is an area of active and ongoing research. Today's asymmetric conflicts, in particular, have been a driving force in the development of unmanned technologies for air, ground, and surface urban operations. Much of the technology development has included efforts to get autonomous vehicles to cooperate with supervising humans and with other autonomous vehicles. However, the need to be able to detect, track, and ID elusive humans operating in complex urban settings will require a new set of sensing, recognition, and human robotic interaction technologies to be developed to allow UAVs to collaborate with UGVs to cooperatively search, detect, track, and ID. A key enabler will be active vision which is the integration of control into conventional sensing and navigation to allow the sensor and platform performance to be adapted in real time to achieve optimum scene understanding.

PHASE I: The Phase I research will identify the critical technology challenges necessary to demonstrate UAV-UGV collaborative tracking, synthesize advanced design for active vision, perform concept feasibility analysis and define the Phase II approach to include field demonstration involving a small UAV and UGV operating under human robotic interface control. Phase I risk reduction studies and experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach. Phase I will focus on defining the architecture and conops design as well as identifying the algorithm requirements.

PHASE II: In Phase II, development and integration of the active vision and human robotic interface must be completed. It will focus on demonstrating the automatic target recognition and tracking/geo-location of elusive suspects using the integrated active vision sensing and the UAV / UGV collaborative tracking interface. If funding permits the integrated technologies will be demonstrated in field with actual or surrogate small UAV and UGV.

PHASE III DUAL-USE COMMERCIALIZATION: Active vision and human robotic interface technology developed under this effort has immediate application for cooperative systems operated for border patrol, homeland security, and first responders.

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KEYWORDS: human robotic interface, active vision, UAV, UGV, cooperative tracking

TPOC: Dr Rob Williams
Phone: 937 212 4051
Fax: 937 656 4414
Email: robert.williams@wpafb.af.mil
2nd TPOC: Dr. Devert Wicker
Phone: 937-904-9871
Fax:
Email: devert.wicker@wpafb.af.mil

OSD06-UM3 TITLE: Human-Robot Manipulation for Complex Operations

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

OBJECTIVE: To provide research that focuses on enhanced capabilities and autonomy for existing manipulator and end effector payloads on unmanned platforms to reduce the burden of manual control by the operator. The enhanced capabilities include increased accuracy, simplified operation, automatic targeting, increased repeatability, increased flexibility, greater dexterity, and rapid deployment. The technology solutions should be cross-platform compatible for easy integration on varying manipulators.

DESCRIPTION: Currently deployed unmanned systems being used to support IED neutralization operations are equipped with multi-degree of freedom arms, which require the operators to maneuver each component of the arm separately and precisely. The work is tedious, exhausting, and highly inefficient. There are a number of technologies capable of addressing these issues to automate the control of the manipulator payloads, including but not limited to:

1) Robotic manipulator parameter identification software and tooling components that enable accurate “first time” positioning of otherwise inaccurate arms
2) Closed loop controls that permit function such as teach and repeat, auto homing, and visual targeting, and force feedback
3) Magnetically levitated wrist and operator interface for increased manipulation and force feedback
4) Kinematic algorithms for manipulator payloads
5) Stereo-vision-based visual targeting
6) Interchangeable manipulators and tools

PHASE I: Phase I will consist of researching one or more of the above and similar technologies and identify the strengths and weaknesses of each scenario. From this data, trade off studies will be performed to determine what characteristics are preferred and to recommend which technologies will best suit various system needs.

PHASE II: Phase II would consist of developing prototypes of the technologies and/or integration with existing manipulator arms and end effectors specified in Phase I and would also include validation testing of these prototypes in operational scenarios.

PHASE III DUAL USE COMMERCIALIZATION: The development of advanced manipulation capabilities for human-robot interfaces has applications in commercial, Department of Energy, and military settings, such as those used for search and rescue, explosive ordnance disposal, mine sweeping, and surveillance and reconnaissance in all unmanned systems domains (air, land, surface, underwater).

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KEYWORDS: autonomous robotic manipulation, multi-degree of freedom arms, vision-based targeting, force feedback control, adaptive tracking control, kinematic algorithms, unmanned systems

TPOC: Estrellina Pacis
Phone: 619-553-2554
Fax: 619-553-6188
Email: estrellina.pacis@navy.mil
2nd TPOC: Brandon Sights
Phone: 619-553-9196
Fax: 619-553-6188
Email: sights@spawar.navy.mil

OSD06-UM4 TITLE: Command and Control of small robotics assets

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

OBJECTIVE: Develop technology to support command and control of a small unit equipped with unmanned systems, as well as collective training in that arena.

DESCRIPTION: The vision of the Future Force is a network-enabled distributed team of human and robotic assets, which can create a real time view of the battlespace, and quickly funnel information where it needs to go (TRADOC, 2002). Troops on the ground are already being equipped with small unmanned air and ground vehicles (UAVs and UGVs) intended to improve situation awareness (Crane, 2005; Mawn, & Tokumaru, 2004). In the future, the Class I UAV and a small UGV will be organic platoon assets. However, prototype systems have not been designed to facilitate information flow from the robots to small unit commanders. Moreover, no systematic training exists for team coordination in the employment of unmanned systems for small teams (platoons or squads). To reach full potential, information obtained from a UAV or UGV must be able to send filtered (not raw) real time information to small unit leaders (e.g., sniper on the roof of building 30 meters to your northwest).

Dedicated planning, rehearsal and execution tools are required to support maintenance of a common operating picture between the commander and robotics operator. Particularly for execution, these tools must be sensitive to the workload burdens on each party and provide a way to filter and/or structure sensor data. At the robotics side, these tools must be able to interact with the robotics control station. At the commander side, the tools must be host-able on portable on-the-move hardware. The possibility of fusing information from multiple robotic platforms should also be considered.

The purpose of this project is to provide these supporting tools. By using a combination of live, virtual, and constructive simulation, the researchers will be required to demonstrate the superiority of their innovative approach over the methods that currently exist. In particular, the objective is to show that a small unit commander is able to utilize robot-provided information during an ongoing mission, without neglect of competing responsibilities or becoming overloaded. In order to facilitate training, these tools should include the ability to capture information pertinent to after-action review (AAR), for example, information about leader – operator coordination. Proposers are encouraged to consider innovative methods such as augmented reality, rapid construction of 3-D models, multi-modal interfaces, and adaptable intelligent automation.

PHASE I: This is a 6-month effort to test the scientific, technical and commercial merit and feasibility of a particular concept.

- Gather information from all available sources with respect to operator-commander coordination needs. Sources can include data from simulation experiments, robotic field testing scenarios, or actual military fielding in theatre of operations. Sources can also include interviews with personnel having participated in above activities.
- Analyze the information for common threads. Characterize the information the commander needs from the robotics operator, and vice versa. Characterize the information they both need to access to maintain a shared situation awareness.
- Design software tools that would support commander-operator communications during platoon level mission execution.
- Determine hardware tools that could host the software, with the constraint that commander tools must be host-able on hardware that is easily portable and can be used on the move.
- Define the experimental methods that will be used to assess the tools. This should include a clear description of the measures of human performance that will be taken. Experiments can be conducted using a combination of live, virtual, or constructive simulation.
- Determine how automated data collection processes can be embedded in the tools, for data that will support experimentation and for data that could contribute to training feedback and After Action Review (AAR).
- Describe results in a detailed final report.

PHASE II: This is the prototype delivery and evaluation phase.

- Construct and demonstrate the prototype tools designed in Phase I.
- Involve the target user community through a process of spiral development.
- Evaluate the ability of the prototype tools to meet the identified requirements, and demonstrate advantages over existing methods using a combination of live, virtual, and constructive simulation.
- The Phase II deliverables will be demonstrations of the prototype, experimentation with human participants in relevant operational scenarios, and a detailed research report outlining findings.

PHASE III DUAL USE APPLICATIONS: In Phase III, it is anticipated that the team will be able to develop this prototype into actual software tools that will be employed by the Army to facilitate coordination between commanders and remote robotics operators. The product may also be desired by other branches of the military. Phase III should include consultation with military experts and training developers to ensure development of automated AAR tools. The product could also be applied in nonmilitary contexts in which robotics will undoubtedly start to proliferate such as search and rescue, emergency response, industrial accident response, and homeland security.

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KEYWORDS: Command and Control, unmanned systems, workload, communications, training, robotics, situation awareness

TPOC: Paula J. Durlach
Phone: 407-384-3983
Fax:
Email: Paula.Durlach@peostri.army.mil
2nd TPOC: Larry Meliza
Phone: 407-384-3992
Fax:
Email: larry.meliza@peostri.army.mil

OSD06-UM5 TITLE: Peer-to-Peer Embedded Human Robot Interaction

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

OBJECTIVE: Develop methodologies and technologies to enable mobile robots to communicate with and understand the actions of dismounted persons encountered and to collaborate with single operators as peers.

DESCRIPTION: The DoD is currently investing in a variety of unmanned systems designed for units at the battalion level and below. A number of these systems are being adapted for use in the rapidly changing environment of the global war on terrorism with the challenges of littoral and urban operations, the threat of chemical and biological weapons, the difficulty in differentiating enemies from neutral civilians, and the need for better force protection. Because of the major threat that IEDs have posed to troops in Iraq, and the importance that urban and littoral operations have assumed in recent conflicts, mobile robots are being rushed into service in large numbers. However, many of these systems have significant manning requirements in terms of the skills of operators required to operate these systems effectively. This is particularly challenging in a dynamic battlespace environment. The need for improved human control and collaboration with these robots in is acute. One issue that limits the use of robotic and autonomous systems in urban environments is their inability to recognize and interact with persons who may be either non-combatants or threats. For example, soldiers manning checkpoints are exposed to vehicle-borne IEDs, but replacing them with robots requires advanced capabilities in vision and communication between robots and human subjects. Another acute need is improved situation awareness regarding threats from dismounted persons around vehicles, both manned and unmanned, and mobile robots in urban environments. Recent research on spatial-aware cognitive models embedded on mobile robots has shown promise for significantly enhancing human robot interactions by providing a framework for robot understanding of human goals, plans, activities and communications. Research in machine vision is developing new capabilities in human activity and gesture recognition.

PHASE I: Research in Phase I should develop a concept for peer-to-peer embedded human-robot interaction that exploits sensing of human actions and communications including some combination of: machine vision techniques for human activity and gesture recognition, omnidirectional detection and tracking of people in relation to a mobile robot, head finding, head pose recognition, gaze determination, remote physiological monitoring for high stress, human speech recognition, natural language understanding to support human-robot interaction and high level control by operators and peers, language translators, human-machine dialogue, and use of avatars and human face representations to facilitate expressive communication. Ideally this research will be integrated with a computational cognitive model to enable the robot to make inferences regarding the roles, potential threats, goals and communications of humans. Provide the operator with high level communication with the robot and dismounted persons.

PHASE II: Phase II should propose the design and prototype development of a system capable of peer-to-peer embedded human-robot interaction that exploits a critical combination of sensing, communication and reasoning, as described in Phase I..

PHASE III: Development and testing of a fully mobile, self-contained robot capable of interaction with both cooperative and uncooperative humans in a peer-to-peer relationship which provides tactically significant stand-off capabilities to human operators, while retaining high level control. Commercialization potential includes operation of mobile robots in hazardous conditions (Chemical / Biological / Nuclear) in populated areas, police tactical operations such as hostage situations, urban search and rescue where communication with subjects is important, use of robot sentries in high threat conditions, and medical triage under hazardous conditions.

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TPOC:	Dr. Thomas McKenna
Phone:	703-696-4503
Fax:	703-696-1212
Email:	mckennt@onr.navy.mil
2nd TPOC:	Marc Steinberg
Phone:	703-696-5115
Fax:	
Email:	steinbm@onr.navy.mil

OSD06-UM6 TITLE: Collaborative and Shared Control of Unmanned Vehicle Systems

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

OBJECTIVE: To develop and demonstrate integrated human interface and automation technologies to enable small co-located or distributed groups of operators to manage multiple air, undersea, and surface vehicle systems. This will include developing an appropriate level of autonomy, decision aids, and situation awareness tools to support collaborative decision-making in which several operators manage multiple unmanned vehicles supporting the same mission tasks or shared use in which multiple users are using the same unmanned vehicle asset to support different mission tasks. The focus of this effort is not on how multiple vehicles collaborate autonomously with each other or on lower level autonomous vehicle technologies such as vision, sensor processing/fusion, and guidance, navigation, and control. Further, the focus of this effort is on users that operate vehicles at some distance from themselves, so interaction approaches designed solely for users co-located in the same physical space as the vehicle or for interactions directly with other dismounted humans are out of scope of this topic.

DESCRIPTION: Currently, most unmanned vehicle systems have dedicated operators that are responsible for the control and mission management of that vehicle. For the future, it will be important to enable small groups of operators to collaboratively manage groups of unmanned vehicle systems or to share the use of unmanned vehicle services to support different mission tasks. Teams of operators may be distributed (e.g., operators located on three Littoral Combat Ships who are working collaboratively with air, sea, and undersea vehicles) or co-located (e.g., operators working together on a carrier to control a group of Naval ISR and Unmanned Combat Air Vehicles). In some cases, operators may be sharing the use of the same assets for completing different mission tasks (e.g., a marine or soldier attempting to request an ISR service from an unmanned system being controlled at a higher level). Vehicles may have different levels of autonomy and this may drive some of the need for multiple operators. For example, an operator at a common unmanned vehicle command and control station may directly interact with highly autonomous vehicles, but need to work collaboratively with a vehicle or payload operator for less autonomous vehicles. Similarly, different users may have different skills/training and interact with the system at different levels. For example, an operator concerned with unmanned vehicle mission management may need to work with an operator responsible for high-level battlespace management and also operators responsible for vehicle/payload control and sensor data analysis. In some cases, which operators/users are involved may vary over the course of a mission, depending on the mission segment. In the most extreme case, distributed users may just want to request the services of the autonomous systems and require a fairly simple interface that allows them to understand the available capabilities of the system and task the system. However, it is assumed in all cases that all users who interact with the system have relevant skill sets for performing their mission tasks. Interface approaches designed solely for use by users that are co-located in the same physical space as the unmanned system are out of scope of this topic. Further, this topic does not include interface approaches for unmanned system interactions with humans who are noncombatants or threats or not specifically responsible for management of the unmanned system.

A key challenge is how to develop an appropriate level of autonomy, decision aids, and situation awareness tools to support distributed decision-making among collaborating operators or between users sharing the same assets. Of particular interest is mission planning, airspace/waterspace management, re-tasking to support new or changed mission tasks, replanning following contingencies, and monitoring of missions. Systems should be designed to modify autonomy level relative to the needs of the user and as emergent mission needs dictate and deal with conflicts in altering the level or location of control. In cases of shared use, autonomous systems should be designed to provide a reliable "quality of service" to users in a time-critical manner. Approaches should support autonomous and human team members in sharing a common situation awareness as appropriate to the user, particularly relative to aspects of the mission where there is coupling or conflicts between tasks or responsibilities as well as when decisions and changes occur. The focus of this effort is not on how multiple vehicles collaborate autonomously with each other or on lower level autonomous vehicle technologies such as vision, sensor processing/fusion, and guidance, navigation, and control. Finally, the approach should be suitable for air, sea, and undersea vehicles, including aspects such as safety issues for unmanned air vehicles and the communications limitations inherent in most undersea vehicles.

PHASE I: Develop an initial version of the proposed approach for a limited set of mission tasks and platform types with sufficient functionality to demonstrate feasibility and allow some limited evaluation by military operators and domain experts. Ideally, this should include integration with limited-fidelity simulation elements to show closed-loop performance. However, the use of canned data and mock-ups will also be acceptable. Develop metrics to evaluate the system in Phase II and determine how the approach will interface with naval autonomous vehicle systems.

PHASE II: Further develop the proposed approach for a broader set of mission tasks and system types in a more complex dynamic and unstructured environment and integrate them with a higher fidelity simulation and sufficient autonomy components to perform laboratory operator in-the-loop demonstrations and comparison with benchmarks. This should at minimum include multiple operators and both air and sea vehicles. Experiments with live assets may be used when of value to validate simulation results, but are not required. Revise evaluation metrics and interfaces as necessary

PHASE III DUAL-USE COMMERCIALIZATION: Integrate the software with other components in a naval control station and participate in integrated demonstrations of autonomous systems operations

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KEYWORDS: Autonomous Systems, Collaborative Control, Team Situation Awareness

TPOC: Marc Steinberg
Phone: 301-342-8567
Fax: 301-342-8597
Email: marc.steinberg@navy.mil

OSD06-UM7 TITLE: Affect-Based Computing and Cognitive Models for Unmanned Vehicle Systems

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

OBJECTIVE: To develop and demonstrate affect-based computing and cognitive modeling approaches that can be utilized to dynamically modify autonomous behavior in future unmanned systems in a manner which is easily understandable and controllable by human operators and users, but also provides behavior that may be less understandable by hostile forces. This may draw on biologically-based theories of cognition, personality, and affect as an initial inspiration, but then develop them within a more conventional engineering framework.

DESCRIPTION: Current autonomous systems rely very heavily on pre-programmed behavior. The next generation of more advanced autonomy technologies will improve on that by enabling unmanned systems to perform on-board optimization based on pre-defined or operator-defined cost functions and behaviors to achieve goals more flexibly. For the future, it will be desirable to have broader ways by which human beings can interact with complex autonomous systems in a relatively simple manner. This is true for both more traditional unmanned vehicle operators and small units or manned assets that may collaborate with unmanned systems. Cognitive models, personality, and affect may provide useful abstractions to enable a human being to rapidly understand the worldview of an autonomous system and modify the behavior of an unmanned system or team and how it perceives its immediate and long-term situation. This type of abstraction would also be one that potentially could be easier for a user to understand, but generate behavior that was more unpredictable to an enemy. For example, an aggressiveness trait could be used to simultaneously increase limits on an inner loop control system, increase the aggressiveness of maneuvering trajectories at the guidance level, allow the vehicle to move closer to the terrain by a collision avoidance system, allow the vehicle to adopt riskier route plans at an auto-routing level, allow the vehicle to adopt higher certainty thresholds for threat avoidance in a situation awareness component, and to attempt riskier goals at a higher level mission planning level. Similarly, high aggressiveness could be combined with high inquisitiveness to modify internal parameters throughout the autonomy hierarchy to have an unmanned system that focused on investigating new targets of opportunity and getting back new ISR data no matter the cost. Alternatively, a very low aggressiveness parameter could be set to drive an unmanned system to complete as many mission tasks as it could without risking threat of detection or loss of the vehicle to the greatest extent possible. Use of this technology to improve the ability to interact with human users and with other manned platforms and small units is particularly important for the naval littoral and urban environments where there may be limited manning and limited communications bandwidth available. A key challenge is to develop systems that can maintain an internal motivational state and use it to produce intelligent behaviors in ways that are consistent with the understanding of the human beings it is interacting with (operators, users, and human beings on manned assets it may be cooperating with). This needs to be done relative to both short and long range time scales. In addition, there are significant integration challenges given the likelihood that changes throughout an autonomy hierarchy may have unpredictable effects on total performance if the nonlinear dynamic interactions between parameter changes in different components are not fully understood. Finally, despite this new level of complexity, it is important that the unmanned system's will continue to maintain safe and reliable behavior as appropriate to the circumstances under which they are utilized.

There are currently many different computational models used by researchers to capture cognitive processes and the interaction between time-varying affect-related phenomena of human beings and animals. Many of these models are currently not well suited to application to engineering problems of autonomy for unmanned systems. As a result, an important part of this effort will be adapting biologically-based approaches to fit within a more conventional engineering framework. Of most interest are approaches that have some applicability to a range of classes of unmanned systems including air, ground, and sea vehicles.

PHASE I: Develop an initial version of the proposed approach for a limited set of mission tasks and platform types with sufficient functionality to demonstrate feasibility and allow some limited evaluation by military operators and domain experts. This should include integration with limited-fidelity simulation elements to show closed-loop performance and as much robustness testing as is feasible within the scope of the effort. Develop metrics to evaluate the system in Phase II and determine how the approach will interface with naval autonomous vehicle systems.

PHASE II: Further develop the proposed approach for a broader set of mission tasks and system types in a more complex dynamic and unstructured environment and integrate them with higher fidelity vehicle simulations and sufficient autonomy components to perform laboratory operator in-the-loop demonstrations and comparison with benchmarks in operator in-the-loop simulations. Experiments with live assets may be used as appropriate to validate simulation results. There should be a strong focus on understanding the sensitivity and robustness of the proposed approach. Revise evaluation metrics and interfaces as necessary.

PHASE III DUAL-USE COMMERCIALIZATION: Integrate the software with naval autonomous systems and participate in integrated demonstrations of autonomous systems operations

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TPOC: Marc Steinberg
Phone: 301-342-8567
Fax: 301-342-8597
Email: marc.steinberg@navy.mil

OSD06-UM8 TITLE: UAV – Combat Medic Collaboration for Resupply & Evacuation

TECHNOLOGY AREAS: Air Platform, Weapons

OBJECTIVE: The purpose of this topic is to design, develop and demonstrate enabling technologies for delivery of medical supplies and Life Support for Trauma and Transport (LSTAT) systems by Unmanned Aerial Vehicles (UAVs) to combat medics for treatment, stabilization and subsequent evacuation of combat casualties from hostile situations. The key research foci of this SBIR topic are advanced technologies for 1) autonomous UAV take-off, landing, and navigation in urban and wooded terrain, and for 2) collaboration and coordination between human combat medics and UAV team members to effect safe and timely delivery of medical supplies and LSTAT systems so that appropriate first responder care and evacuation can be performed by combat medics during the so called “golden hour” of combat casualty care.

DESCRIPTION: Buddy treatment, first responder combat casualty care, timely delivery of essential medical supplies, and evacuation of casualties under hostile fire historically are integral to combat medical support but they curtail added risk and loss of life. Force protection of military first responders is complicated by increased involvement in peace keeping operations, counter terrorism, and humanitarian assistance missions that involve politically sensitive low intensity combat and combat in urban terrain; these operating environments may involve asymmetric warfare or employment of weapons of mass destruction. Battlefield medicine is moving toward adoption of several new technologies to both improve the quality of care and protect healthcare providers. With advances in medical technology, what was formerly considered secondary or even tertiary care is moving closer to the point of first response. One example of this trend is use of the Life Support for Trauma and Transport (LSTAT) patient transport litter in combat conditions of Kosovo, Afghanistan, Southeast Asia and Iraq, where LSTAT devices have been field tested by the Army. With its integrated patient monitoring and life support capabilities, LSTAT represents state-of-practice in battlefield medicine allowing patients to be cared for with less direct attention by medics during transport to field medical facilities. Current operational experience has shown that while the LSTAT is too heavy to be routinely carried by medics into battle, such a system is critical to life saving support during combat casualty stabilization and evacuation. Future Combat System (FCS) and US Marine Corps doctrine provides for small units of action with embedded medics and medical teams. Since these units of action are capable of rapid movement over wide areas of terrain, the Army has documented a requirement for a lighter LSTAT type device called a CSTAT (Critical Care System for Trauma and Transport). Once developed, even a lighter LSTAT/CSTAT type device needs a rapid just-in-time delivery method to be effectively employed by lightweight rapidly moving Future Combat System Unit of Action Teams and Marines. The military has invested significant research funding in autonomous ground and aerial vehicles and has demonstrated some rudimentary combat medical resupply operations using UAVs in open terrain However, significant research remains to be performed in adapting, integrating, or developing new UAV team member technologies sufficient to enable 1) autonomous UAV take-off, landing, and navigation in urban and wooded terrain, and 2) collaboration and coordination between human combat medics and UAV team members to enable timely and safe delivery of critical medical supplies and equipment such as the LSTAT during the golden hour of combat casualty care. An objective or this SBIR topic is to leverage similar UAV research performed by government laboratories, universities, and private industry for such sponsors as the Defense Advanced Research Projects Agency (DARPA), the Special Operations Command, and the National Aeronautics and Space Administration (NASA). However, no existing prototypes are sufficiently large enough to carry adequate payloads of medical supplies and/or LSTAT systems, AND sophisticated enough to negotiate urban or wooded terrain at low level or to self-select suitable landing zones sufficient for autonomous landing and takeoff with only minimal human team member guidance. Specific technical research challenges yet to be solved include development of devices and algorithms or heuristics to 1) plan and execute approach and regress routes in all weather condition, within both urban and wilderness terrain with or without preloaded maps or terrain models; 2) communicate with and facilitate communications between UAV and human medic team members; 3) detect and avoid hazards or hostile situations; and 4) plan and conduct recovery from errors or the unexpected.

PHASE I: Formulate a concept for design of a UAV as a combat medic team member capable of delivering critical medical supplies and LSTAT systems to the site of combat injury in urban or wooded terrain. Develop conceptual and technical models which identify and translate functional requirements into implementable technical UAV system designs which demonstrate feasibility of the concepts and capabilities defined in the Description paragraph above and in the Phase II demonstrable tasks below.

PHASE II: Demonstrate a representative sample of the following tasks:
a. Navigate through urban or wooded terrain to a site of combat injury..
b. Select a suitable site for autonomous landing and take-off with minimal human team member/operator guidance. .
c. Safely land and take-off autonomously (with minimal human team member/operator intervention)
d. Communicate with human medic team members
e. Carry a reasonable payload of medical supplies and equipment to include an LSTAT to the site of injury

PHASE III: Develop and ademonstrate a prototype UAV combat medic team member with the combined capabilities demonstrated in Phase II. Assist the military in transition of the UAV medical team member technology to an Advanced Technology Demonstration and/or Advanced Concept Technology Demonstration. Once validated conceptually and technically, the dual use applications of this technology are significant in the area of civilian emergency services; this technology could potentially save many lives among military and civilian casualties and injured persons. Coordinate with civilian first responders and Homeland Security agencies to transition the capability to civilian first responders for emergency response in hazardous or contaminated environments or in remote medically underserved areas and eventually commercialize the system.

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TPOC: Gary R Gilbert
Phone: (301) 619-4043
Fax: (301) 619-2518
Email: gary.r.gilbert@us.army.mil
2nd TPOC: COL James McGhee
Phone: (334) 255-6917

Fax:	(334) 255-6937
Email:	james.mcghee@us.army.mil
3rd TPOC:	David Rousseau
Phone:	(619) 553-9221
Fax:	(619) 553-3750
Email:	david.rousseau@navy.mil